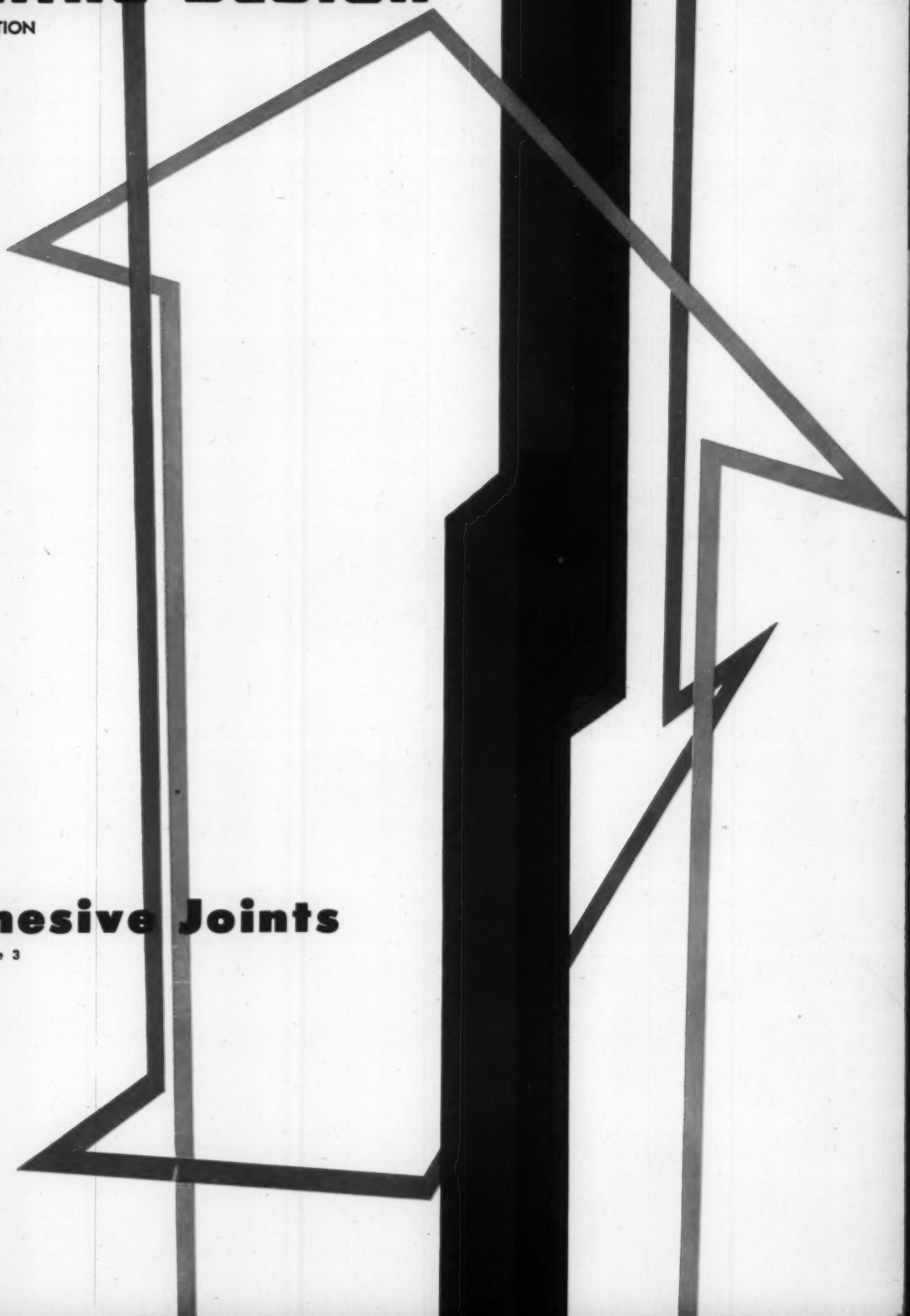
APRIL 4, 1957
EVERY OTHER THUSSDAY

MACHINE DESIGN

A PENTON PUBLICATION



Adhesive Joints

Contents, Page 3

ENSWORTH

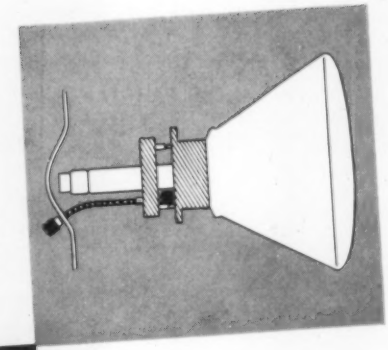
S.S.White

Flexible Shafts Make Operations Easier!

The manufacturer of this hue control for a color TV set uses a standard S.S. WHITE FLEXIBLE SHAFT to cope with a 90° turn. The shaft needs no alignment . . . can be quickly and easily installed. Costs are lower . . . manufacturing is simpler . . . assembly operations are easier, faster.

You can often reduce a complex system of gearing, universals and other parts to ONE FLEXIBLE SHAFT! Flexible shafts also make better designs possible . . . allowing new freedom in locating connected members to save space and facilitate operation and servicing.

For many years, these versatile shafts have been making industrial operations easier. They are tough and rugged . . . yet have the sensitivity you need for delicate adjustments. Design engineers and manufacturers discover new uses for S.S. WHITE FLEXIBLE SHAFTS every day. Can your product be improved by a simple . . . better . . . less costly way of transmitting power or remote control? Our engineers will be glad to work out a flexible shaft application with you. Just write to



USEFUL DATA on how to select and apply flexible shafts. Write for Bulletin 5601.

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Circle 401 on page 19

NEW Ross Starline

air control valve series

NEW long life

WHITE STAR
SPOOL SOLENOID

GOLD STAR
OIL-IMMERSED SOLENOID

BLUE STAR MV

BLUE STAR TD

BLUE STAR WV

NEW match any head to any valve body!

STRAIGHTWAY NORMALLY OPEN

STRAIGHTWAY NORMALLY CLOSED

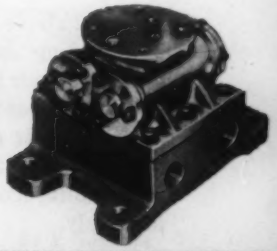
3 WAY NORMALLY OPEN

3 WAY NORMALLY CLOSED

3 WAY NORMALLY OPEN

3 WAY NORMALLY CLOSED

4 WAY



Tests indicate a trouble-free life of over 25 million cycles for valves with the spool solenoid pilot section, and *more than 40 million for all other Starline* valves shown.

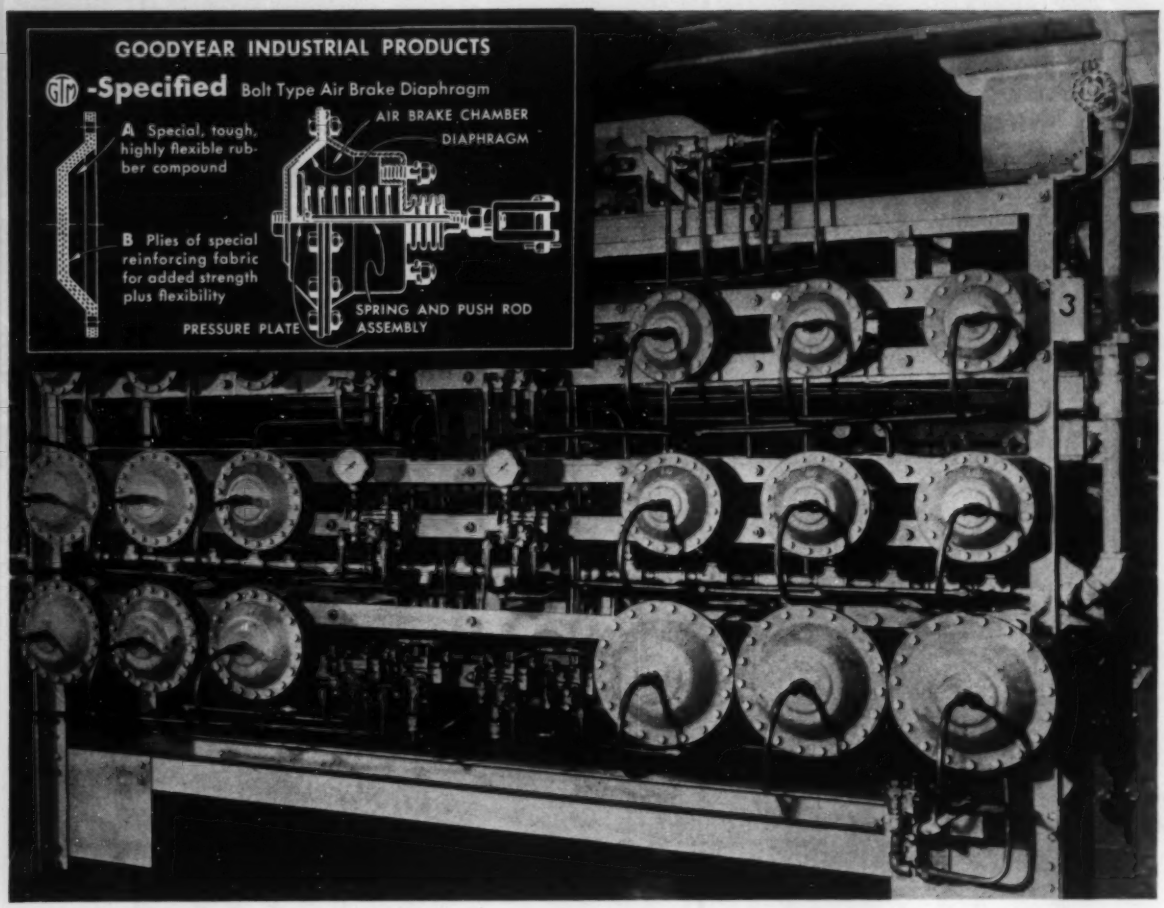
Heads and bodies are completely and instantly interchangeable. Sizes from ¼" to 1¼". Even *more* Starline models coming later. Write for Starline data file.

A Galaxy of New Air-Control Stars Are Coming Your Way From

Ross OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVENUE • DETROIT 3, MICHIGAN

Circle 404 on page 19


GOODYEAR INDUSTRIAL PRODUCTS
GTM -Specified Bolt Type Air Brake Diaphragm
A Special, tough, highly flexible rubber compound
B Plies of special reinforcing fabric for added strength plus flexibility
AIR BRAKE CHAMBER
DIAPHRAGM
PRESSURE PLATE
SPRING AND PUSH ROD ASSEMBLY

Here's A Real Stopper—a million times over!

Pictured above is the diaphragm testing rack of a leading automotive air brake manufacturer. Here air brake diaphragms are made or unmade. These rubber fabric parts must demonstrate their ability to stand up under the punishment of a million braking cycles before their manufacturers are approved as a source of supply.

When the G.T.M.—Goodyear Technical Man—first submitted samples, he admittedly had difficulty meeting the rigid requirements. However, with the close and highly qualified assistance of Goodyear development and production engineers, he soon had a diaphragm which passed the rugged specifications with ease and consistence.

Their work in air brakes is typical of how the G.T.M. and his co-workers can develop special rubber compounds, reinforcing fabrics and manufacturing techniques to answer any diaphragm need. And is another reason why Goodyear is a leading supplier of diaphragms and other molded goods. For details see the G.T.M. or write Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

GOODYEAR

THE GREATEST NAME IN RUBBER

Circle 405 on page 19

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

April 4, 1957
Volume 29—No. 7

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations performing design engineering of products are also eligible.

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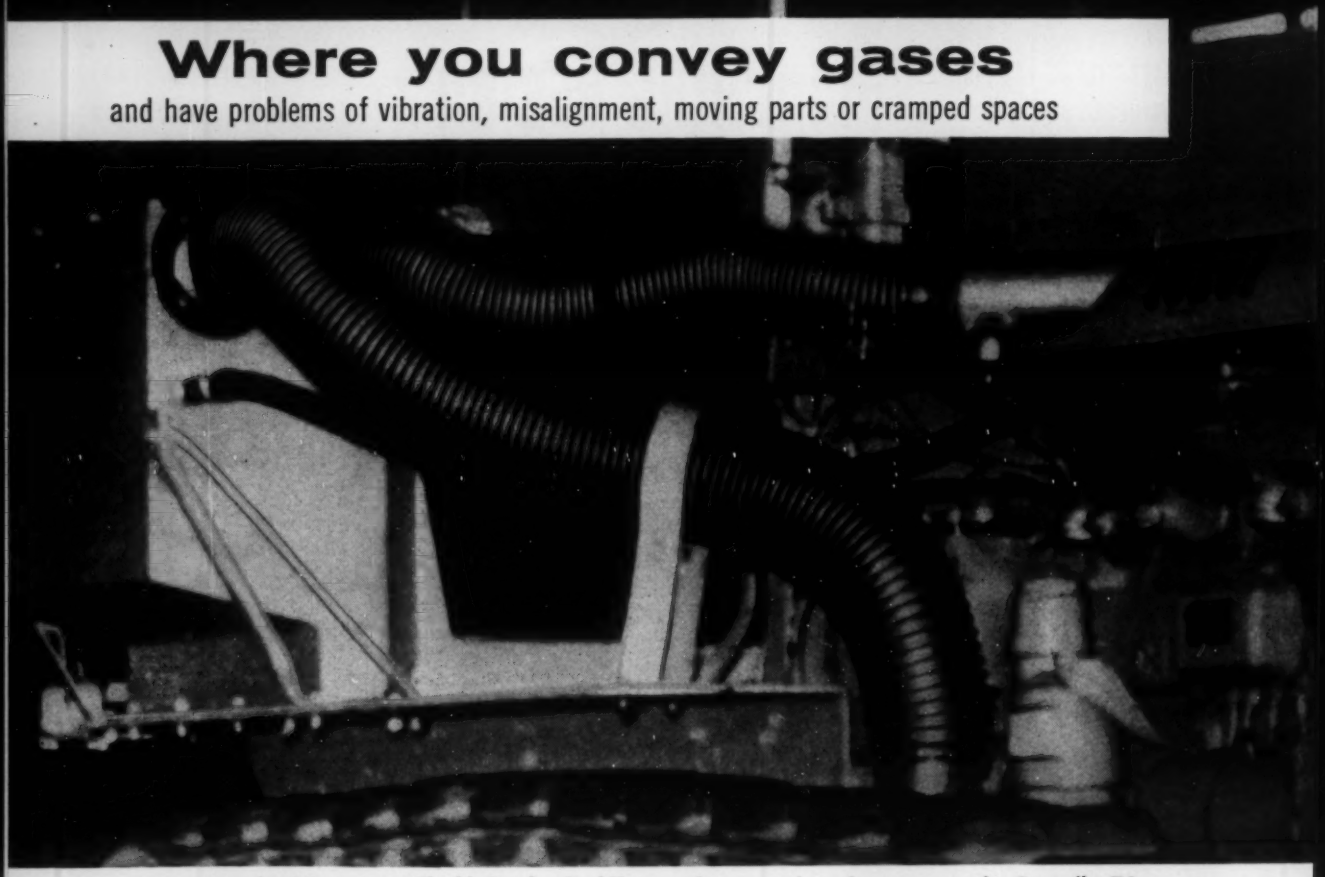
Where you convey gases

and have problems of vibration, misalignment, moving parts or cramped spaces



3" and 4" I.D. American Flexible Stainless Steel Hoses used to convey hot exhaust gases on this Caterpillar D2 Diesel Tractor, equipped with Exhaust Conditioner, used in underground, hard-rock mining operations.

Get more service hours per dollar with American Flexible Metal Hose

Famous quality construction of American Flexible Metal Hose offers you the security of trouble-free, leakproof service in conveying gases, whatever your needs. Proof of this is American's enviable record—in thousands of applications—for the pressure-tight conveyance of air, oxygen, hydrogen, nitrogen, acetylene, propane, butane, Freon, ammonia, and many other gases under both high and low pressures.

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Available in a wide range of diameters in tough, corrosion-resistant bronze, steel, supernickel, brass, stainless steel or other metals, American Flexible Metal Hose delivers the very highest *service hours per dollar*. You can order complete assemblies with end fittings attached—made to your specifications and ready for immediate installation.

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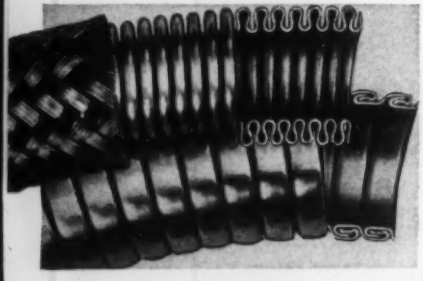
54179 Rev.

WHEREVER CONNECTORS MUST MOVE

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA®** PRODUCT



BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

Circle 406 on page 19

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me a free copy of your new flexible metal hose and tubing catalog, G-560.

NAME & TITLE.....

ADDRESS.....

COMPANY.....

CITY, ZONE, STATE.....

Engineering News Roundup

EARLY-WARNING BIRD sports distinctive topknot which houses radar search gear. This prototype of the Grumman WF-2 Tracer early-warning aircraft tries its wings in first successful test flight. Adapted from passenger-cargo model TF-1 Trader, the WF-2 carries the largest radome yet designed for a carrier-based airplane. Radome shape, airfoil in section, is compromise between aerodynamic and electronic ideals. Split tail avoids radome wake effects. Folding wings economize carrier storage space. On patrol at sea, WF-2 will carry two pilots and two radar operators.

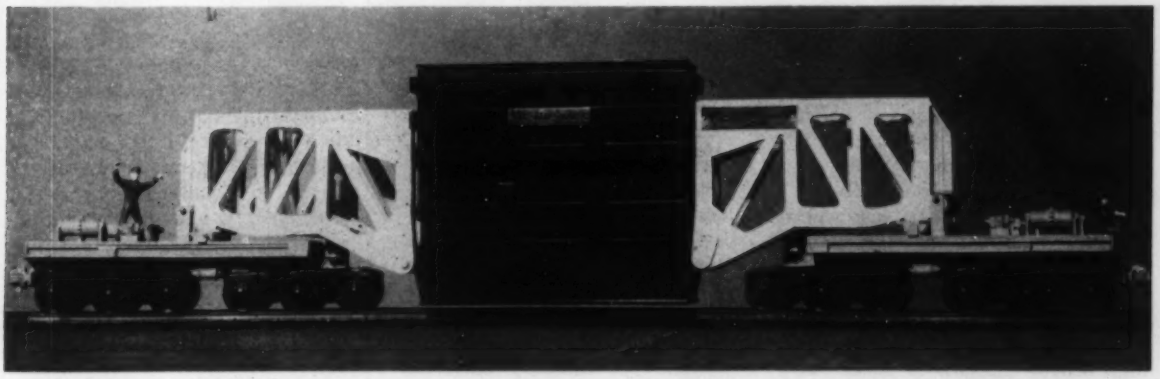
Seek Aides, Pay, Praise To Ease Engineer Shortage

Engineers Also Specify Improvements for Schools

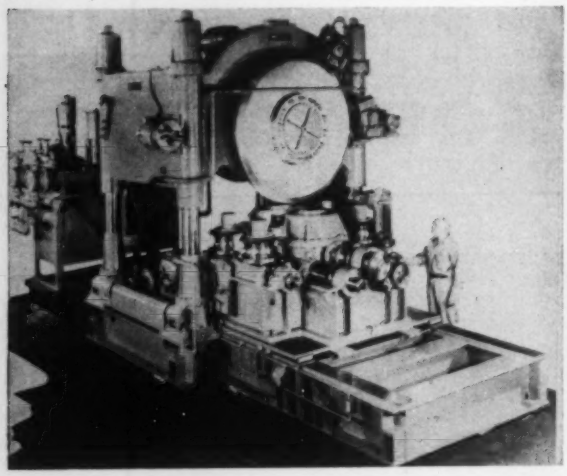
NEW YORK, N. Y. — Engineers themselves have indicated that the best short-term method of meeting the current engineer shortage is to increase the productivity and improve the status of engineers now employed in industry. Their favored long-term solution is to increase enrollment of engineering students. Many indicated also that college curriculums should be improved.

These were results, made public recently, of an ASME survey of members attending the society's latest annual meeting. Asked for measures to end the shortage, 65 per cent of all respondents suggested changes in industrial practices. In the order of frequency, these steps dealt with:

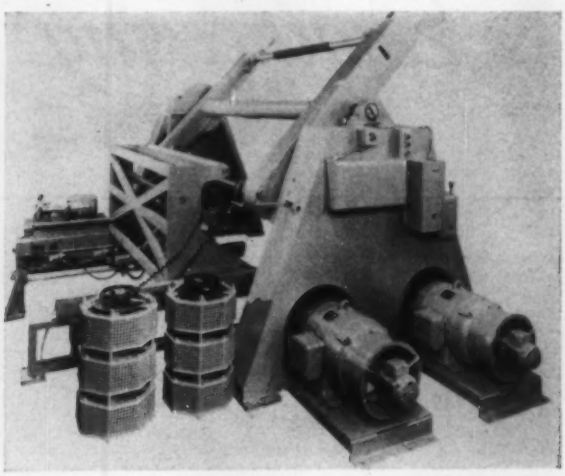
1. Providing engineers employed in industry with more technical assistants and clerical help, thereby free-



THREE-PART CAR, first of its kind in this country, has load capacity of 500,000 lb, will carry power transformers up to 28 ft long, 12 ft wide. Transformer itself is the center car section. Suspended between trusses on car end sections, transformer rides 6 in. above rails where former minimum clearance was 48 in. On car end sections, truss pivot points are above inside trucks and load centers are between trucks. Rollers permit lateral motion of load centers on curves. At each load center, two 100-ton jacks help load and unload transformers while 30-ton jacks at pivot points handle the trusses. Car ends join, via trusses, for return trip.



LARGEST WELDER of rotary electric type is claimed for this unit built by McKay Machine Co. The welder is part of a new mill to produce 12-in. diam steel pipe. Transformer coolant specified for the welder is noninflammable, has good dielectric properties but is poor lubricant. To circulate this type coolant, machine incorporates three-stage, vertical turbine pump on 500-gal tank at rear of welder to give 70 gpm at 60 psi.



CONTINUOUS WINDING is assured by this new power-operated two-shaft turret winder developed by Hobbs Manufacturing Co. Custom designed for use back of an extruder laminator, the Hobbs-Alquist winder accommodates rolls of poly-coated cellophanes and kraft or plain papers up to 1500 lb. Automatic cut-off and roll starting mechanism saves time formerly spent to stop the process, install and reset new roll.

ing professional men for more creative work (31 per cent).

2. Increasing salaries to make the profession more attractive to youngsters and to qualified engineers who have been lured to other fields by higher pay (21 per cent).

3. Improving the recognition and prestige accorded to engineers for their contributions to the economy (12.5 per cent).

Commenting on the survey, Dr. William F. Ryan, ASME president, said, "The idea that engineers need more subprofessional assistance is a recurring one. So is the suggestion of higher salaries . . . . In my own opinion the most urgent salary problem is the compensation of teachers in engineering schools . . . . Most fundamental, perhaps, is the well-founded feeling that engineers and their contributions to our economy are not sufficiently appreciated."

Additional questions on the survey dealt with the adequacy of high school and college education. Tabulations according to the year in which the respondent graduated indicated that older men appeared to be slightly more critical of today's high schools and colleges than younger men. Suggestions on improving college preparation for engineering were classifiable into these categories:

Improve nontechnical courses	28%
Improve technical courses	24
Extend the present four-year college program	13
Enlist the support of industry	10
Better teachers and better facilities	5
More applied courses	4
More pay for teachers	2
Improve vocational information	2
Higher entrance requirements	2
Miscellaneous	10

First Miniature FM Radio To Enter Commercial Market

Leads Line of FM Sets With Individualized Features

CAMDEN, N. J. — The first commercial pocket-size FM radio receiver is scheduled for general distribution late this year. The set measures 2¾-in. wide, 1 in. thick, and 6½-in. high; weighs approximately 10 oz; operates in the 150-megacycle band on self-contained flashlight-type mercury batteries. Power required is a fraction of a watt.

Introduced by RCA, the small radio is currently undergoing nationwide field tests conducted by municipal police departments, fire departments, and various other government agencies.

Fully transistorized and featuring printed circuitry, the pocket-size double superheterodyne FM receiver incorporates its own antenna and loudspeaker, obviating need for a separate ear piece. The new set can be contacted directly by the sending station without the use of additional equipment.

In operation, the experimental receiver is carried in the pocket in an "on" position, enabling the carrier to hear all messages transmitted by the sending station on its frequency. The receiver can be factory-adjusted for reception on any VHF channel in the 150-megacycle band. The receiver's exceptionally low power requirements, resulting from the low power drain

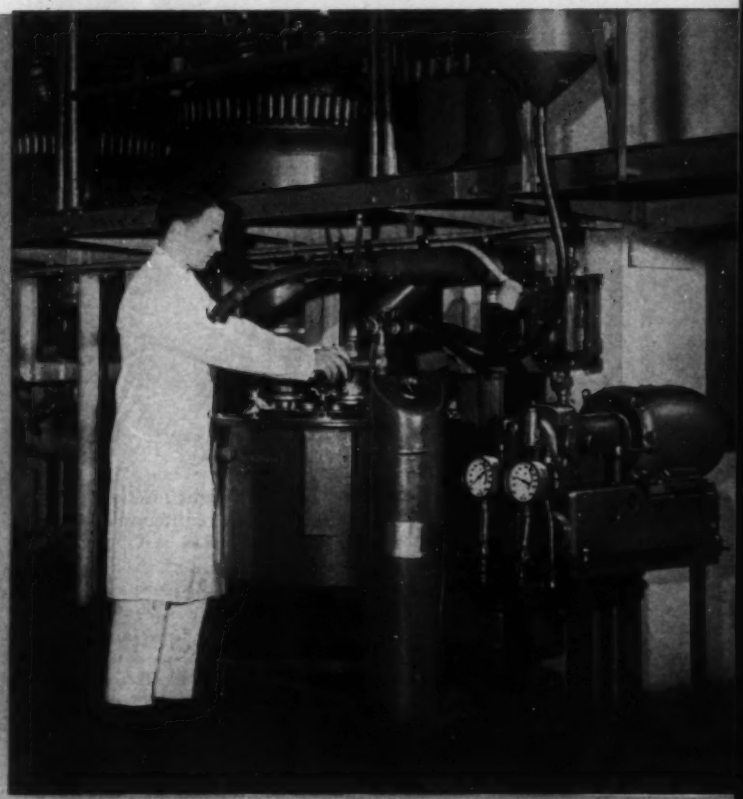
Front Cover

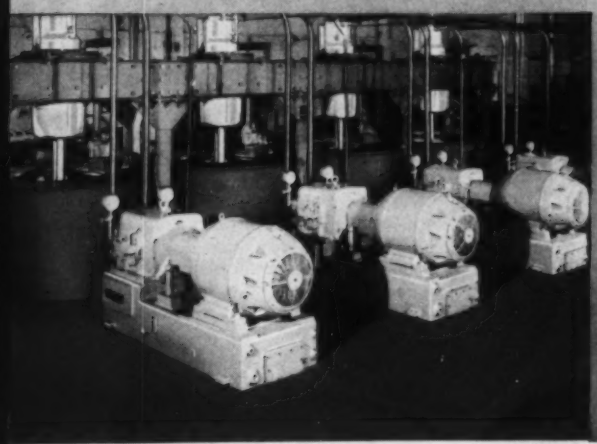
A simple test specimen of an adhesive joint being stressed in tension-shear provides the theme for artist George Farnsworth's front cover. Harold Tombach's article, "Adhesive Joints," on Page 113 provides the keynote idea.

Any speed for you too!

Unique Oilgear Fluid Power "ANY-SPEED" Drives establish new production and economy records

Any desired speed from zero to maximum . . . any rate of acceleration . . . any rate of deceleration . . . any rate of hydrodynamic braking . . . any speed adjustment between operations . . . synchronization of two or more drives . . . direct or remote precision speed control irrespective of load, input power or oil viscosity changes . . . all with Oilgear Fluid Power "Any-Speed" Drives. Old and new users name them *"the drives"* for their heavy-duty needs. You probably didn't know this! Every day, people are equally surprised—*and far more amazed when they know the facts.* Write and get them *now*. THE OILGEAR COMPANY, 1568 W. Pierce Street, Milwaukee 4, Wisconsin.





This Centrifuge at Abbott Laboratories

Leading house in pharmaceutical, drug and chemical field, Abbott Laboratories installed first Oilgear Drive on Tolhurst centrifuge in production department. Experience was so satisfactory it led to the inclusion of another Oilgear equipped Tolhurst centrifuge in their experimental laboratories.

SPECIFICATIONS: Speed continuously variable from zero to 1200 rpm max. (in this case). Full control of acceleration/deceleration speed and rate. Permits that infinitely modifiable speed best suited to loading, washing, spinning and unloading.

Photo Courtesy, Chemical Processing Magazine

This Centrifuge at powder plant in east

In a somewhat different application, these 4 Oilgear 60 hp "Any-Speed" Drives serve Tolhurst centrifuges in powder plant in the east. Centrifuge accelerates to 300 rpm for loading, to 900 rpm for 15-minute centrifuging, then decelerates to 70 rpm for "plowing." Unloading is automatic.

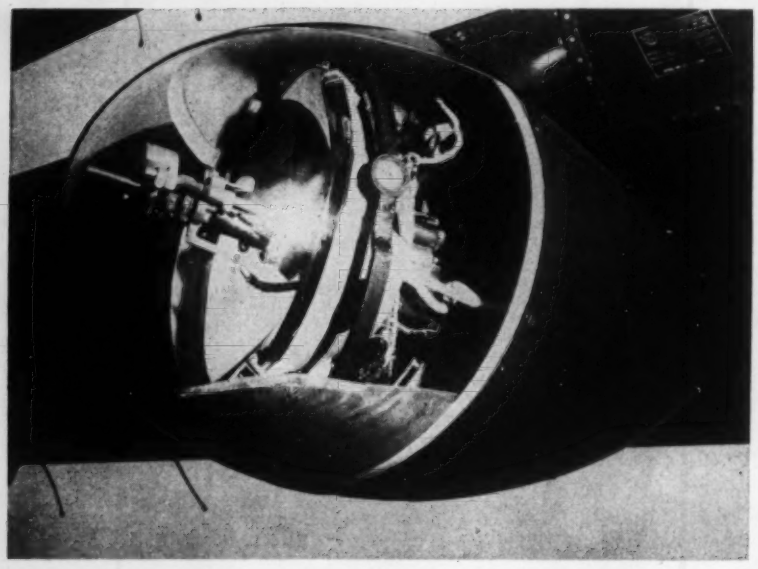
Tolhurst is a division of American Machine & Metals, Inc.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

Please direct inquiries to advertiser, mentioning MACHINE DESIGN



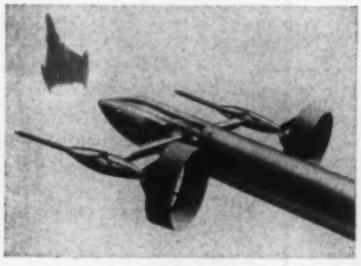
MIDNIGHT SUN, a new carbon-arc searchlight intended for antisubmarine search and rescue duty, delivers 130-million candlepower—the equivalent of 10,000 upper-beam auto headlights. Designated AN/AVQ-3, the light was developed for the Navy by Arma Div. of American Bosch Arma Corp. Its diameter is 20 in.; length, 94 in. Illumination is produced by vaporization of the positive carbon and burning of negative carbon. Unlike preceding models which need rest after 30 seconds, the new lamp can shine as long as carbons last. It can be aimed by radar or manually, does not rely on secondary identification unit like scope, tape, tonal sound or record.

characteristic of transistors, makes possible efficient "on" operation of the unit over extended periods of time.

RCA states that the new radio is the forerunner of a wide assortment of microminiature equipment in the three commercial two-way radio bands of 50, 150 and 450 megacycles. Subsequent models of personalized radios will enable person-to-person communication, absentee notification of messages received, and will have novel battery-saving features.

Instrument Now Measures VTOL Transition Airspeed

ANAHEIM, CALIF.—A new aircraft instrument now enables measurement of angles of attack and sideslip at the relatively low airspeeds experienced in planes that take off and land vertically. The instrument was developed for Ryan Aeronautical Co. by Task Corp. Ryan had found it essential to measure the true air velocity during transition from vertical to horizontal flight.



Two-pound instrument developed for VTOL aircraft gives true airspeed in critical transition flight.

Mounted on a nose boom, the Task device is a special wind vane with two degrees of rotation. Two swiveling heads, located opposite each other on the nose boom tip, measure flow direction and pitot-static pressures, respectively. The heads swivel freely to align them-

Topics

Golden atoms may some day keep cars cool. Ford researchers have bombarded glass with pure gold atoms to produce an extremely thin layer of gold that excludes heat rays but lets light rays through.

• • •

Five-year glow has been provided for entrance and escape door hatch handles on B-52 bombers to serve as a guide in the event of a night emergency involving power failure. Light source is a small piece of specially treated metal, Strontium-90, which is safe-sealed in a transparent plastic button.

• • •

Cutting of steel with ceramic tools has been accomplished at the record rate of 16,454 sfpm. The industrial engineering research laboratory of Ohio State University, conducting a research project for Warner & Swasey, cut a blank of 1040 steel to a depth of 0.040-in. Cutter life was, as expected, very short.

• • •

High-temperature pumps, capable of maintaining close tolerances at 300 F, provide auxiliary power for supersonic aircraft. Four of the new Hamilton Standard pumps are used in Convair's B-58 Hustler to operate elevons, rudder and flaps; to raise and lower landing gear; and to operate radar equipment. Each delivers up to 35 gal of hydraulic fluid a minute at 3000 psi.

• • •

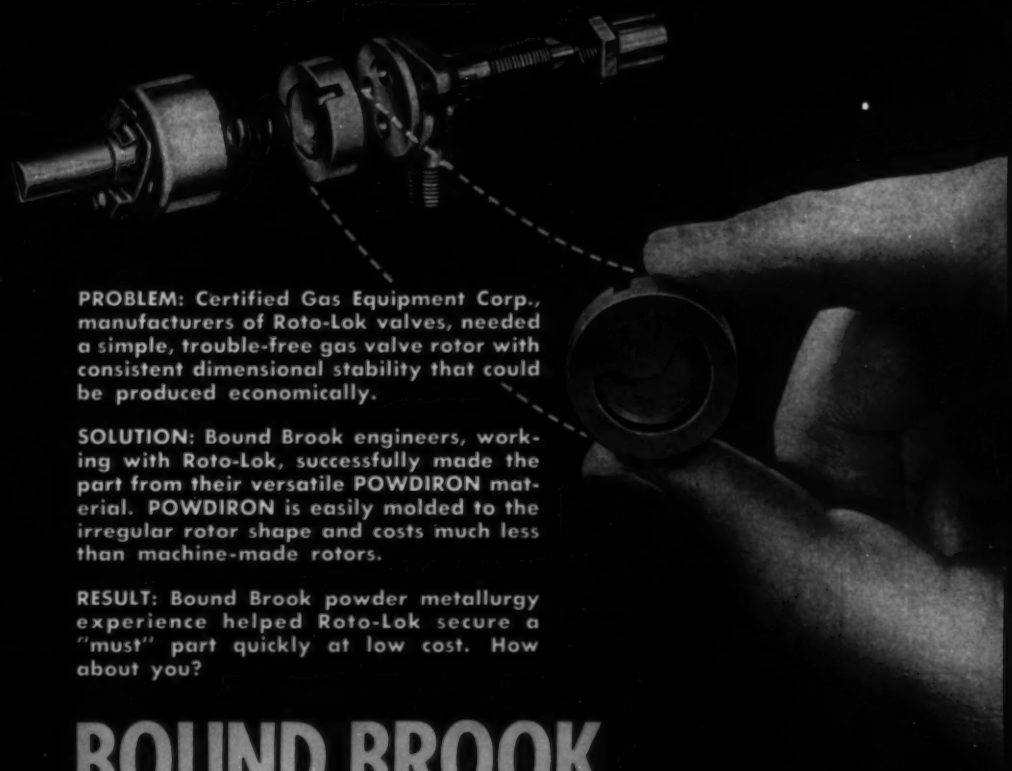
Over 7000 miles to the pound of uranium is the performance record of the *Nautilus,* which recently docked for refueling and installation of a new generator. Better fuel performance is expected with the new generator. It is estimated that a conventional submarine of comparable size would have used 300 tank cars, or 22,500,000 lb of fuel oil to travel the 60,000 miles covered by the *Nautilus.*

• • •

Bigger beeps will be built into future automobiles. Higher road speeds, more traffic noise and better insulation of cars make louder horns necessary for safety, according to manufacturers.

Circle 407 on page 19→

BOUND BROOK KNOW-HOW, PLUS ROTO-LOK QUALITY *BLASTS* DESIGN, COST *BUG-A-BOO*



PROBLEM: Certified Gas Equipment Corp., manufacturers of Roto-Lok valves, needed a simple, trouble-free gas valve rotor with consistent dimensional stability that could be produced economically.

SOLUTION: Bound Brook engineers, working with Roto-Lok, successfully made the part from their versatile **POWDIRON** material. **POWDIRON** is easily molded to the irregular rotor shape and costs much less than machine-made rotors.

RESULT: Bound Brook powder metallurgy experience helped Roto-Lok secure a "must" part quickly at low cost. How about you?

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

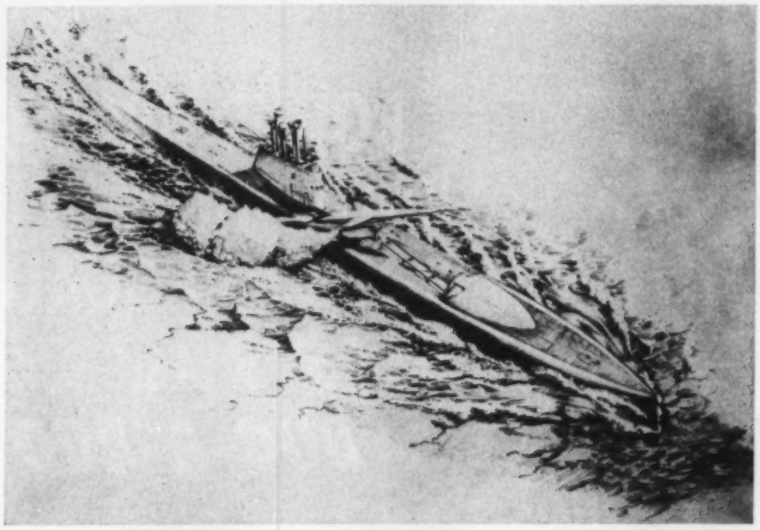
ESTABLISHED 1883

selves with the relative airflow.

The flow-direction head has two toroidal potentiometers, centered on the two axes of rotation, which yield electrical signals proportional to the angle of attack and angle of sideslip.

The second swiveling head measures total and static pressures in the conventional manner. Since the head centerline is always aligned with the airflow, maximum accuracy of the pitot-static reading is assurred.

Location of the static orifices was determined by tests in the Free Surface Water Tunnel at California Institute of Technology. Calibration of the pitot-static readings, using the complete head assembly, took place in the GALCIT wind tunnel, also at Cal Tech, over a wide range of angles of attack, angles of sideslip, and dynamic pressures.



NUCLEAR PROPULSION PLANT for this first atomic-powered guided missile submarine is being designed by Westinghouse for the Navy. Artist's sketch shows the 346-ft ship with missile and launching system. Westinghouse is also working on the first nuclear power plant for a surface ship.

Farm Tractor Is First with Free-Piston Turbine Engine

Field Tests Indicate Operating Economies

BIRMINGHAM, MICH. — An experimental farm tractor powered by a free-piston turbine engine, believed to be the first in this type vehicle, is now ready for field testing and design refinement. This is announced by the Tractor and Implement Div., Ford Motor Co. Ford's name for the tractor is Typhoon.

Actual production of the tractor is still in the future, but experience to date indicates good prospects for fuel economy, simplicity of operation and minimum maintenance.

Much of the expense and complexity of the mechanical power train used in current internal combustion engines is eliminated. Crankshaft, camshaft, connecting rods, mushroom-type intake and exhaust valves and spark plugs are not required. Nor does the engine need the high-temperature-resistant metals used in conventional

Typhoon farm tractor, announced by Ford Tractor and Implement Div., is the first known to be powered by free-piston turbine engine. Here it tows dynamometer at Birmingham, Mich., proving ground.

(Advertisement)

Design data on adhesives

Armstrong

ADHESIVES • COATINGS • SEALERS
USED WHEREVER PERFORMANCE COUNTS

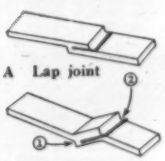
NUMBER ONE

How to design joints for adhesives

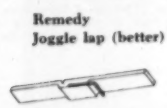
Many common joints can be re-designed to give maximum strength with adhesives. The examples shown do not cover every situation, but they do illustrate how four basic design rules can be applied to improve strength. These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which the adhesive is weakest.

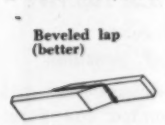
Strengthening a lap joint:



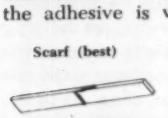
Under stress, a common lap joint such as "A" tends to deflect as the assembly aligns itself. Instead of a simple shear stress, the joint in effect more nearly resembles drawing "B". The tension effect at edges "1" and "2" tends to peel the bond apart, since a high proportion of the load is carried at the edges of the lap.



Greater proportion of bonded area now contributes to strength. (Rule 2) Stress is now reduced in the direction in which the adhesive is weakest. (Rule 4)



Even greater proportion of bonded area now contributes to strength (Rule 2) Stress is further minimized in the direction in which the adhesive is weakest. (Rule 4)



Maximum proportion of bonded area now contributes to strength. (Rule 2) Adhesive is now stressed in the direction of its maximum strength. (Rule 3) Stress is now minimized in the direction the adhesive is weakest. (Rule 4)

Production line application of adhesives

It is as important to choose the right method of applying the adhesive as it is to select the proper adhesive.

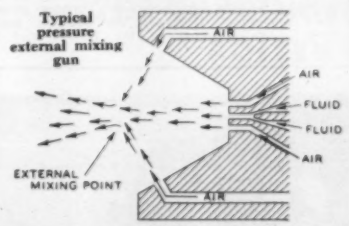
A straight-line manufacturing process with parts handled by a mechanical conveyor obviously is the most desirable setup. The adhesive is applied at the first stage, the adhesive film prepared for bonding in the second stage, and the application of pressure, if necessary, in the third stage.

The methods of application most suitable to straight-line production are spraying and roller coating.

1. Spray coating

Spray coating offers the same advantages for adhesives as for paints. Adhesives ranging from water-thin resins to viscous synthetic rubber products and even abrasive-filled materials are applied in this manner.

Some adhesives and coatings may be applied as an even, perfectly smooth film. Materials of this type should be sprayed with a pressure type (not suction) external mixing gun. The intermediate nozzle or fluid opening sizes ordinarily used for paints will control the amount of fluid ejected into the air stream, so that all of the fluid is "atomized." Fast-drying adhesives, particularly those based on synthetic rubber, cannot be applied with



paint smoothness, but will spray with uniformity in almost any thickness desired. Selection of the correct air gap and fluid opening is important. Large fluid openings are better with viscous adhesives, but only if air pressure can be increased proportionately. With synthetic rubber type adhesives, higher air pressure is usually needed for breakup of the fluid stream.

Adhesives of this type can be improved by lowering the viscosity by dilution, using the recommended solvent. In using an adhesive that has been severely thinned, it must be remembered that solids content is low.

In many applications, the speed and economy offered by automatic spray equipment will quickly repay the investment required. Where the nature of the work requires hand spraying, some of the more important points are: hold the gun no more than 7" or 8" from the work; "trigger" the gun at the end of each pass rather than attempt to operate the gun continuously; hold the gun at right angles to the work to insure uniform film thickness.

2. Roller coating

Where continuous production runs of sheets of one thickness are involved, roller coating is fast and economical.

If properly compounded, most water base adhesives will roller coat on standard equipment.

Fast-drying adhesives of the synthetic rubber type require slight machine modification and a different technique. Most solvents for adhesives will attack rubber or plastics so that metal rolls must be used throughout. Synthetic rubber adhesives tend to adhere to the applicator roll and will not apply uniformly from a smooth-surfaced roll. To remedy this, the roll should contain "reservoirs" for the adhesive and enough surface irregularity to prevent suction. This may take the form of grooves at right angles to the roll axis or small cups engraved on the roll. In either case, the area between the grooves or the cups should be cross-hatched or broken up in some way. The amount of adhesive applied is determined by the depth of the machined "reservoirs" and their spacing.

While the coater is in use, the adhesive should be prevented from losing solvent by evaporation, which increases viscosity. To do this, the adhesive should be fed to the pan continuously at the used rate. The pan should be covered or the adhesive stirred in the pan for uniform feed to the take-up roll. Production should be as nearly continuous as possible.

For more information on adhesives—and design problems involving adhesives—write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, Industrial Div., 8004 Dean Street, Lancaster, Pa.

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gas turbine or jet engines.

Although the power plant is capable of producing 100 hp, the experimental Typhoon utilizes only half of this potential. Several operating advantages of the engine already are apparent. Fuel economy appears promising. Engine friction is substantially lessened by the reduction of moving parts. Vibration is virtually eliminated.

Engine Specifications

Type: Free-piston gas generator turbine, two-stroke diesel cycle.

Cylinders: One, with two horizontally opposed free pistons.

Engine cylinder data:

Bore (in.)	3.75
Effective engine stroke (in.)	4.2
Mechanical compression ratio	15 to 1

Gas temperatures (deg F, max.):

At time of ignition	1000
At turbine inlet	940 to 960
At turbine exhaust	750

Pressures (psi):

Air box at intake ports	22 to 40
Surge tank	16 to 27
At turbine	15 to 25

Ratio, turbine rpm to rear wheel rpm (first gear): 5600 to 1

Starting cycle: Create vacuum in bounce cylinder to pull pistons apart; push prime button; release compressed air to bounce cylinders.

Tractor Specifications

Type: Dual front wheel row crop.

Measurements (in.):

Overall length	144
Overall height	70
Wheelbase	99

Transmission: Power-shift; ten speeds forward; two speeds reverse.

Power take-off: Independent

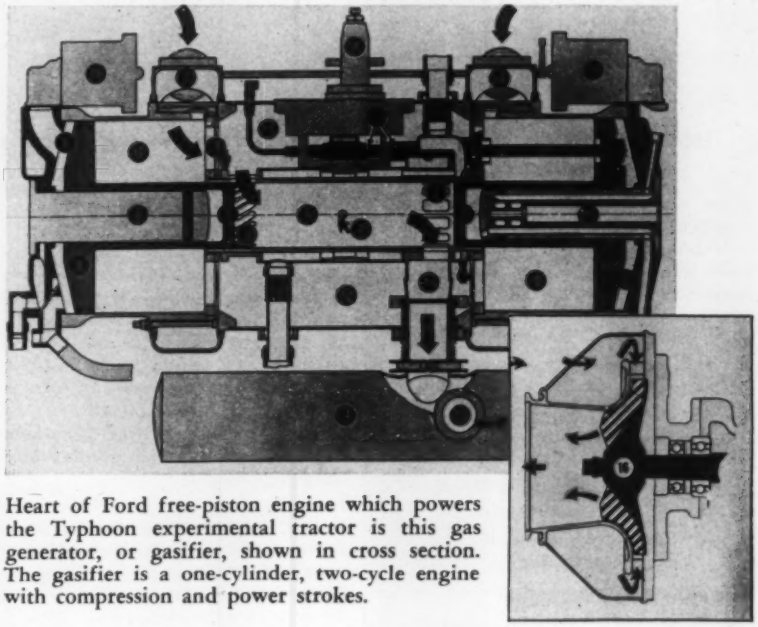
Rear tire size (in.) 13 by 30

Front tire size (in.) 5.50 by 16

Drawbar horsepower (approx.) 50

Instruments: Gasifier cycles per minute, turbine rpm, turbine inlet pressure, fuel pressure, water and oil inlet temperatures, indicator lights for lubrication, battery charge, cooling oil pressure.

Engine accessories (driven by turbine): Radiator cooling fan, water pump, generator, oil pumps (cooling, lubricating and hydraulic systems), fuel pump, tachometer.



Heart of Ford free-piston engine which powers the Typhoon experimental tractor is this gas generator, or gasifier, shown in cross section. The gasifier is a one-cylinder, two-cycle engine with compression and power strokes.

Combustion cylinder, 1, with fuel injection nozzle, 2, is water cooled along its length. Intake ports are at 3 and exhaust ports at 4. Two "free" pistons, 5, are linked together mechanically by a rack and pinion arrangement, 6, so they move inward and outward the same distance and at the same time.

Fuel injector pump, 7, is driven by a cam on one of the racks. The pistons slide on fixed supports, 8, and are oil cooled and lubricated as they move.

In the position shown, the pistons have compressed the air in the "bounce" cylinders, 9. This air acts as a spring to force the pistons toward the middle of the combustion cylinder.

During the compression stroke, air is shoved from the compression cylinders, 10, through reed valves, 11, into the air "box," 12. Entrapped air in the combustion cylinder is also compressed, reaching ignition temperature at the time fuel is injected.

On the power stroke, the pistons are forced outward by the expansion of burning gases. This movement uncovers the exhaust ports first, allowing most of the heated gas to leave the cylinder through the exhaust tube, 13. Then the intake ports are uncovered, and air from the air "box" flows through the cylinder, thoroughly scavenging it and mixing with the hot gases in the surge tanks, 14.

The outward moving pistons compress air in the "bounce" cylinders, and this compressed air again provides the rebound to move the pistons inward for the compression stroke. The diluted hot gases flow from the surge tank through a port, 15, to the turbine wheel, 16. The revolving turbine wheel supplies power to the tractor.

As the pistons move outward after the fuel charge has been ignited, outside air is pulled into the compression cylinders through butterfly and reed valves at the air intakes, 17.

To activate the pistons for the initial start of the engine, a vacuum pump (not shown) draws air out of the "bounce" cylinders to pull the pistons back into the position shown. Starting "cans," 18, then provide a measured amount of air under pressure to the "bounce" cylinders to force the pistons inward for the initial compression.

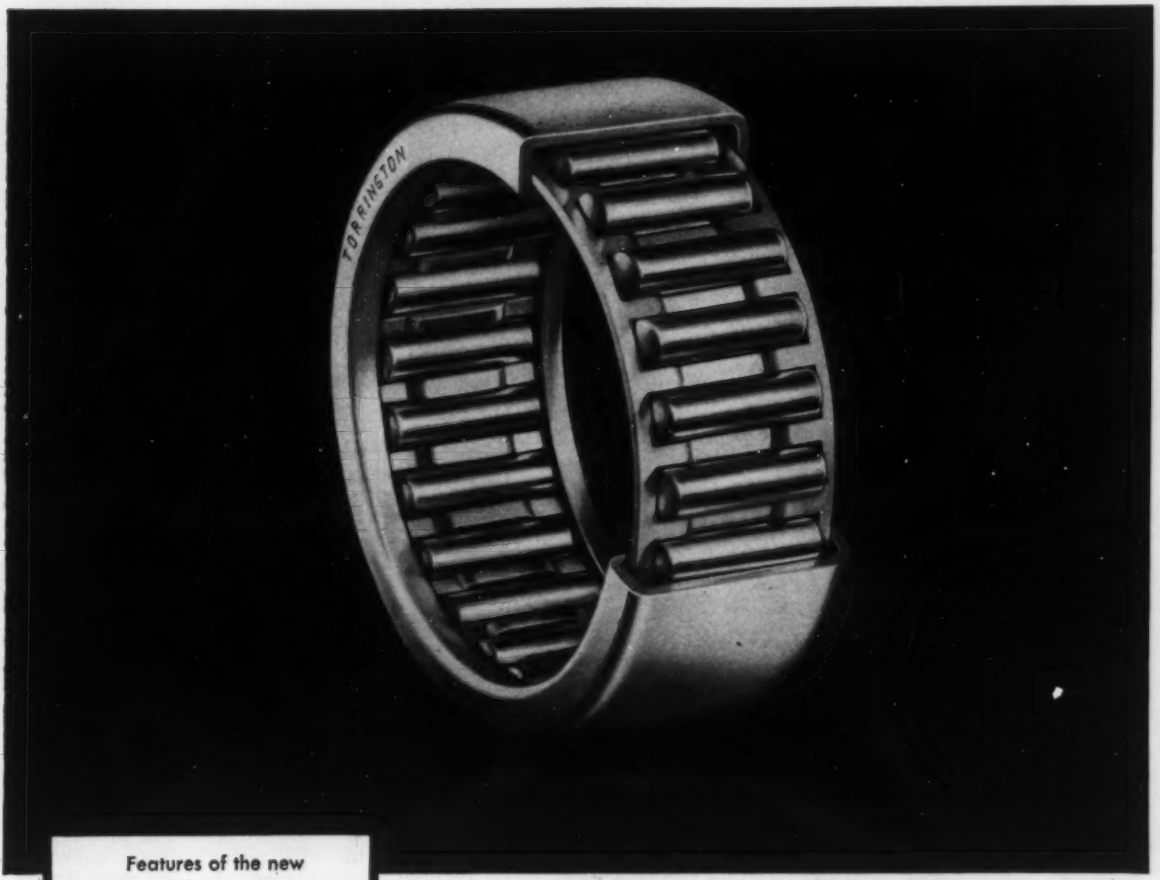
EXTRA SEATING SPACE for two passengers is optional on 1957 Studebaker and Packard Clipper station wagons. The rear-facing third seat folds into the space usually occupied by a spare tire. All three-seat station wagons will be equipped with captive air tires, which, with their ability to travel 100 miles if the outer part becomes punctured, eliminate the need for a spare.

Bigger, Better Design Show Now Ranks With U.S. Top Five

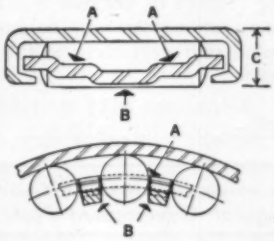
Concurrent Conference Offers Variety of Sessions

NEW YORK, N. Y.—Engineers and designers who attended the First Design Engineering Show in Philadephia last year will be interested to know that a far bigger helping of the same dish awaits them at the second show and conference in the New York Coliseum, May 20 to 23.

Indications are that the second show and conference will be two-and-one-half times the size of the first. Attendence is expected to reach 20,000, including visitors from at least a dozen foreign



Features of the new
TORRINGTON DRAWN CUP ROLLER BEARING



- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
- high capacity in small cross section (C)
- long pregreased life
- efficient at high speeds
- mounted by press fit
- simple housing design
- low unit cost

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a new low-cost precision roller bearing...

THE TORRINGTON DRAWN CUP ROLLER BEARING

For the first time, the advantages of drawn cup outer race construction are available in a precision roller bearing.

This compact, lightweight bearing consists of spherical end needle rollers, a one-piece hardened steel retainer and case-hardened thin-section outer race. Designed to run on a hardened shaft or with an inner race, this new series takes a press fit in a simple housing without snap-rings or shoulders.

Highly efficient roller guidance and lubrication are outstanding features. The shaft-riding retainer contacts the roller ends at the pitch line where guidance can be obtained with the least effort. The design provides ample storage for lubricant and promotes its circulation.

These features make the new bearing particularly suited to applications requiring compactness with precision, high-speed endurance or long pregreased life.

For information on sizes now available and for application assistance, call on our Engineering Department or write for the new bulletin, "Torrington Drawn Cup Roller Bearings." THE TORRINGTON COMPANY, Torrington, Conn. — and South Bend, Ind.

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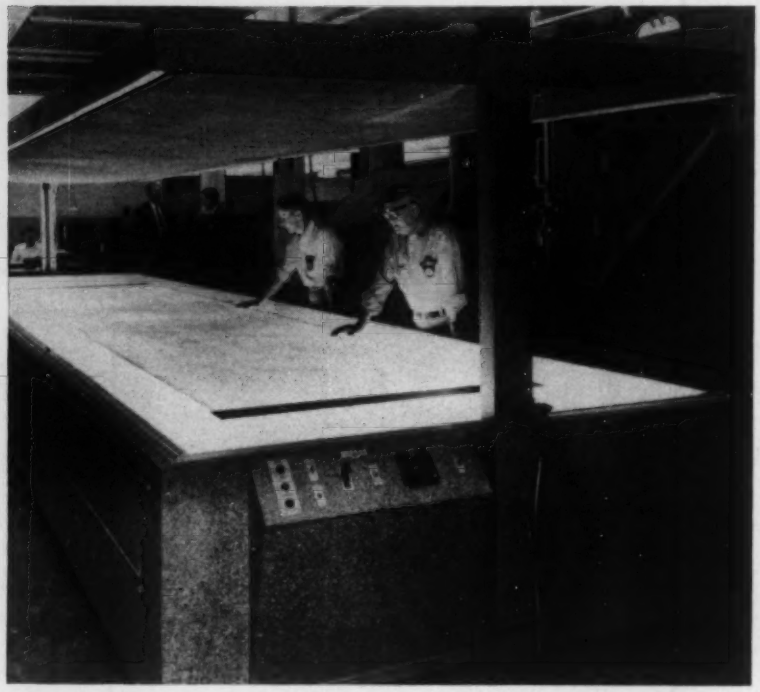

LARGEST CONTACT PRINTER is believed to be this model, 30 ft long, made by Miller-Trojan Mfg. Co., used by North American Aviation for aircraft tooling duplication. Two sections, end to end, form printing surface 360 by 72 in. Vacuum assures contact of masters with sensitized surfaces of metal, fiber board or paper. Light source is GE rapid-start fluorescent lamps. Lids move vertically on powered ball-bearing screws. Switch control enables two halves to operate independently or simultaneously.

countries. These figures place the Second Design Engineering Show and Conference in the top five events of this kind in the U. S. in 1957. It continues to be the only show devoted exclusively to the design engineer's needs. It is significant that the show, thus directed, has attained this outstanding growth in just one year.

Credit in large measure goes to the committee of magazine editors who planned the first conference. An expanded, more selective program for the second conference has been arranged by the same men. They are: Colin Carmichael, editor, MACHINE DESIGN; George F. Nordenholt, editor, *Product Engineering*; Henry R. Clauser, editor, *Materials & Methods; and* Frank Oliver, editor, *Electrical Manufacturing.*

Program for Monday morning, May 20, is a panel discussion on the subject, *Procedures in Developing New Designs.* Panel chairman is George Nordenholt, and panel members are selected engineering managers of industries and societies nationwide. On Tuesday and Wednesday mornings, May 21 and 22, conference visitors will have their choice of mechanical, materials or electrical sessions. Tuesday chairmen, respectively, will be Colin Carmichael, Henry R. Clauser and Frank Oliver. Wednesday chairmen, respectively, will be Harold Sizer, director of design for machine tools, Brown & Sharpe Mfg. Co.; Carl Massopust, director of research and development, Plastic Div., General American Transportation Corp.; and Dr. Cuthbert C. Hurd, director of automation research, International Business Machines Co.

Conference on Welding Engineering will be held at the Army Corps of Engineers Research and Development Laboratories, Fort Belvoir, Va., April 29-May 1. Case histories of service failures in welding, influenced by design, specification or inspection, and their engineering causes and cures will be discussed by a panel of experts.

Private industry and government agencies are invited to submit such histories, including solutions where possible, to Allan L. Tarr, ERDL Materials Branch, Fort Belvoir, Va. Firms submitting suitable accounts or records of unusual welding failures in service will be invited to send representatives to the conference.

Attendance is by invitation only. Plans call for publishing the pa-

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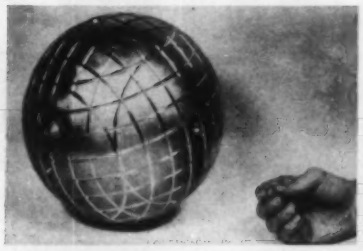

STAINLESS STEEL BALLS, 230 lb each, allow movement of bridge support column ball joints without resultant high bending stresses. Made by Industrial Tectonics Inc., the balls are grooved to retain a graphite paste lubricant.

Host of Plans and Projects Mark AEC's First Ten Years

WASHINGTON, D. C.—A formidable fleet of fighting ships, all atom-powered, is one of many items the Atomic Energy Commission finds in a list of U. S. accomplishments in the atomic energy field on January 1, 1957. This date is the AEC's 10th anniversary. For the occasion, the commission reviewed the events in a decade of significant developments and inventoried the federal atomic energy program as of today.

The commission divides its history into three significant periods. The first, from 1947 to 1949, was one of rehabilitation, reorganization and recruitment.

In the second period, 1950 to 1953, all phases of the program were expanded.

The third and current phase is marked by three principal trends: International co-operation to extend peaceful uses of atomic energy, more participation in the program by independent industry, and the release of technical information formerly classified for security purposes.

As the AEC begins its second decade, the inventory of U. S. plans and projects includes military applications, like the prototypes of the Navy's atom-powered fleet, as

(*Continued on Page 22*)

DRAFTING TRENDS

POST's handy checklist can speed up your Drafting Room Checkup and serve as a reminder of possible places where you can increase drafting efficiency.

The trend to thorough equipment checkups

Stepped-up production in the plant almost always means stepped-up activity on the board. Unfortunately, there is rarely time to stop and take stock of what is happening to drafting room efficiency as the work load increases. It is often necessary to improvise with what you have, or hastily expand as the need occurs.

With the shortage of manpower obviously continuing, it is apparent that a careful, critical review of drafting methods and equipment can lead the way to greater productivity. Department heads in some companies are setting aside a specific time every year to *completely analyze the drafting room.* The trend is to planning additions, improvements and reorganizations during such checkup periods.

One way to pinpoint possible increases in productivity is to go, item by item, through a checkup-list showing every type of product used in a modern, well-equipped drafting room. Such a list is available from the Frederick Post Company. It covers equipment and supplies from A to Z and suggests where you can make improvements.

Here are some typical examples of what you might look for during a Checkup: Cutting down waste motion by using modern drafting tables and drafting machines; eliminating time-consuming methods by using special grid-lined sketch pads, templates and other devices; reducing fatigue and increasing comfort by installing newer equipment; saving space with up-to-date files, etc.

Whatever the need, a logical, well-planned analysis of current and contemplated drafting operations is likely to unearth improvements.

Trained specialists in complete checkups

Practical assistance in making your checkup can be obtained from your POST supplier, who frequently helps make such efficiency surveys. He is experienced in all phases of drafting room operation and is a valuable source of ideas for everything from a major reorganization to producing hard-to-find supplies. Call your POST supplier and ask him about some of the techniques other companies use in surveying drafting room operations and boosting productivity. You will find his thinking a valuable addition to your own appraisals.

For more information and a POST checkup-list, write to the Reader Service Division of the Frederick Post Company, 3652 N. Avondale Ave., Chicago 18, Ill.

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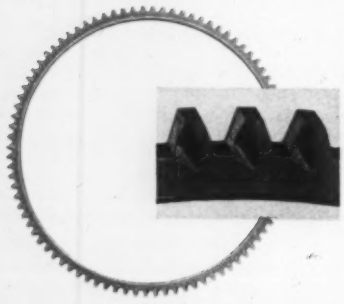
Today's outboards GET GOING with Double Diamond Flywheel Starter Gears



Major makers of electric-starting outboards come to Automotive Gear for their flywheel starter gear requirements. They get our extensive experience in making millions of them for the automotive field—plus skilled engineering aid—plus keen respect for their specifications—plus flame-hardening for better, longer gear performance—plus good delivery.

If you are powering a product, why not talk to the company that specializes in power transmission via gears of many types? An engineer will respond to your inquiry.

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

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APR. 4, 1957

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FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

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Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

Does A Big Job

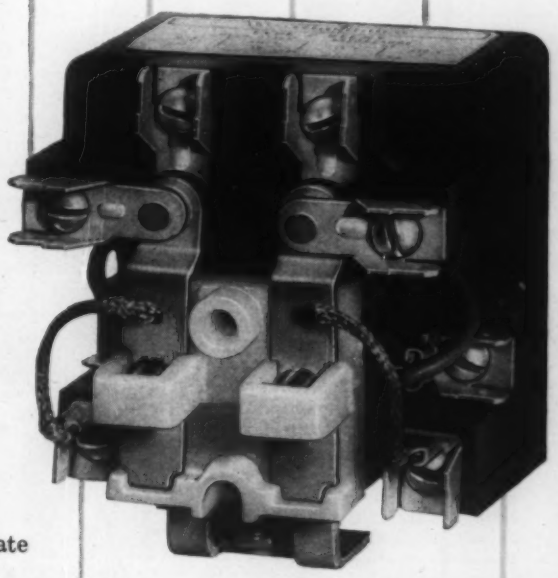
Takes Less Space

TYPE Z RELAY

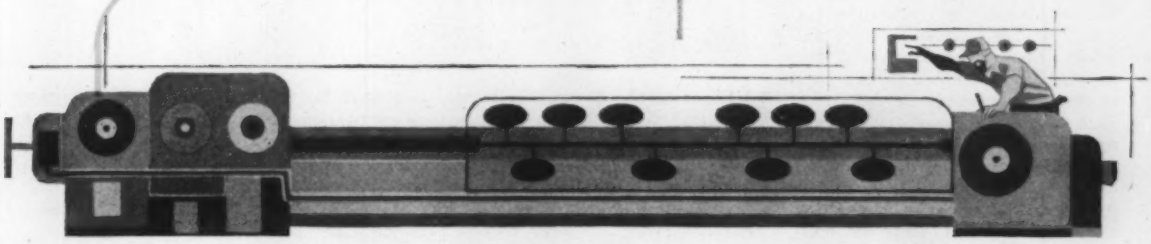
by Westinghouse

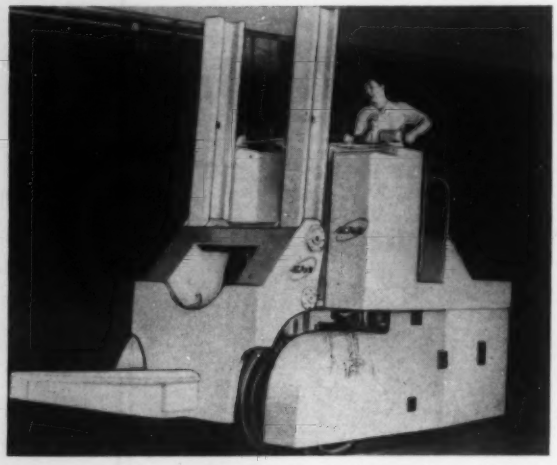
Small, versatile, amazingly rugged, this new Westinghouse relay is designed for long life and high reliability. The relay user who has space problems . . . wants a lot of relay in minimum mounting space finds Type Z ideally suited. Type Z meets U. L. Standards for 230 volts, is equipped with double-pole double-throw contacts of fine silver. Coil and core are interchangeable for a-c or d-c operation. An ideal relay for auxiliary multiple-circuit switching of light loads, small motors or for operating larger contactors or starters. J-30262

YOU CAN BE SURE...IF IT'S Westinghouse



Nylon armature insulating plate
Encapsulated removable coils
Firm contact pressure, low resistance





DUAL DRIVE MOTORS enable heaviest of new Elwell-Parker lift trucks to handle loads up to 80,000 lb in metalworking plants. Steering and hydraulic brakes are power operated. Lift mechanism has no chains. Centersill type frame and propeller shaft power plants facilitate changes and maintenance.

LIFTING OVER ROUGH SPOTS with loads up to 20,000 lb is the job of this heavy-duty fork truck recently announced by Clark Equipment Co. Pneumatic tires, four-wheel drive and four-speed power-shift transmission enable the new Ranger-200 model to operate in mud and rough ground. With 143-hp GM diesel engine, the truck travels 25 mph forward or reverse. Wheelbase is 108 in.; turning radius, 312 in.

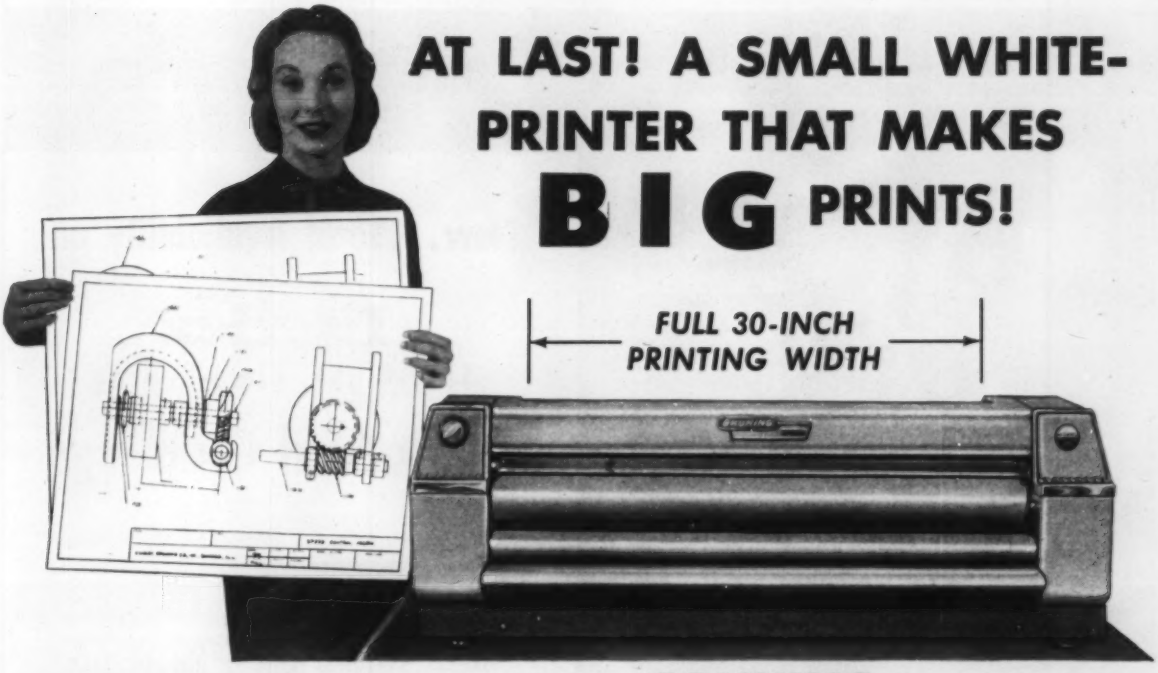
(*Continued from Page* 15)

well as a number of civilian applications:

1. The first full-scale nuclear power plant, a 60,000kw capacity station at Shippingport, Pa., and several smaller-scale power reactor experiments are nearing completion and scheduled to begin operation in 1957.
2. The basic government experimental program which included five reactor types has now been enlarged to include four new reactor concepts which are to be carried at least to the pilot plant stage.
3. American industry is proposing to construct, entirely with its own funds, seven nuclear power plants having an estimated capacity of about 900,000 kw, according to announcements by the companies involved.
4. Congress has authorized a $42-million nuclear-powered cargo ship which is being designed and built as a joint project of the AEC and the U. S. Maritime Commission. The program for nuclear propulsion of military aircraft has moved ahead steadily. An experimental, transportable nuclear power plant being constructed by the Army at Fort Belvoir, Va., is expected to be in operation in mid-1957.
5. Five nongovernmental or private research reactors have been built, two more are under construction, and 19 more planned.
6. American firms have signed or are negotiating a score of contracts for the design, manufacture and installation of research reactors abroad. Two nations, Belgium and Italy, have contracted for power reactors to be built by American firms. American and Foreign Power Inc. has announced it will install 10,000-

VIA SCOOTER, mail deliveries will soon be stepped up in southern states. Satisfied with Florida performance of Mailster by Cushman Motor Works, Post Office Dept. will use 1500 more in south, coast to coast, and test a few farther north in snow and cold weather. Fiber glass body has large rear-access hold and smaller compartment behind operator. Four-cycle air-cooled Cushman engine drives Mailster up to 35 mph. The scooter also features two-wheel drive, three speeds forward, one reverse, and electric starter.

AT LAST! A SMALL WHITE-PRINTER THAT MAKES BIG PRINTS!



BRUNING

NEW! Copyflex Model 300!

Brings "Inside" Reproduction within the Means of the Smallest Engineering Firm or Department!

Now, with your low-cost, versatile Model 300, you can make high quality prints when you want them—rapidly, privately, and in any quantity. You can exercise complete control over valuable originals at all times.

Provides Large Companies an Economical Way to Supplement Main Reproduction Centers!

With its compact size, big printing width, and low cost, the Model 300 is an ideal helper for your big reproduction machine. Strategically located throughout your company, Model 300s can bring new speed, convenience, and efficiency to your reproduction operations.

Here it is! The compact, low-cost reproduction machine that offers all the versatility and big printing width of a large, expensive whiteprinter!

Just think—you can make sharp, black-on-white prints in seconds of a drawing or tracing up to 30 inches wide by any length. And anyone can operate the Model 300 after only brief instruction. One fingertip control turns the machine on or off, and regulates its speed. Exposure and development are automatically synchronized.

The new Copyflex Model 300 is ideal for drafting rooms and offices because it can operate anywhere without annoyance to personnel in the vicinity. It is clean, quiet, and odorless. No exhaust venting, plumbing, or accessory equipment required. It needs only a connection with a 115-volt AC outlet for operation.

If you're pressed by the boom in production for more and more engineering prints, the all-new Copyflex Model 300 is your answer! Its low initial cost combined with outstanding economy and convenience of operation and maintenance make it your soundest, low-cost investment of the year. Mail coupon today! You'll be glad you did!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Offices in 37 Cities of the U. S. and Canada

CHARLES BRUNING COMPANY, INC., CHICAGO

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

CHARLES BRUNING CO., Dept. 43-K
4700 Montrose Ave., Chicago 41, Ill.

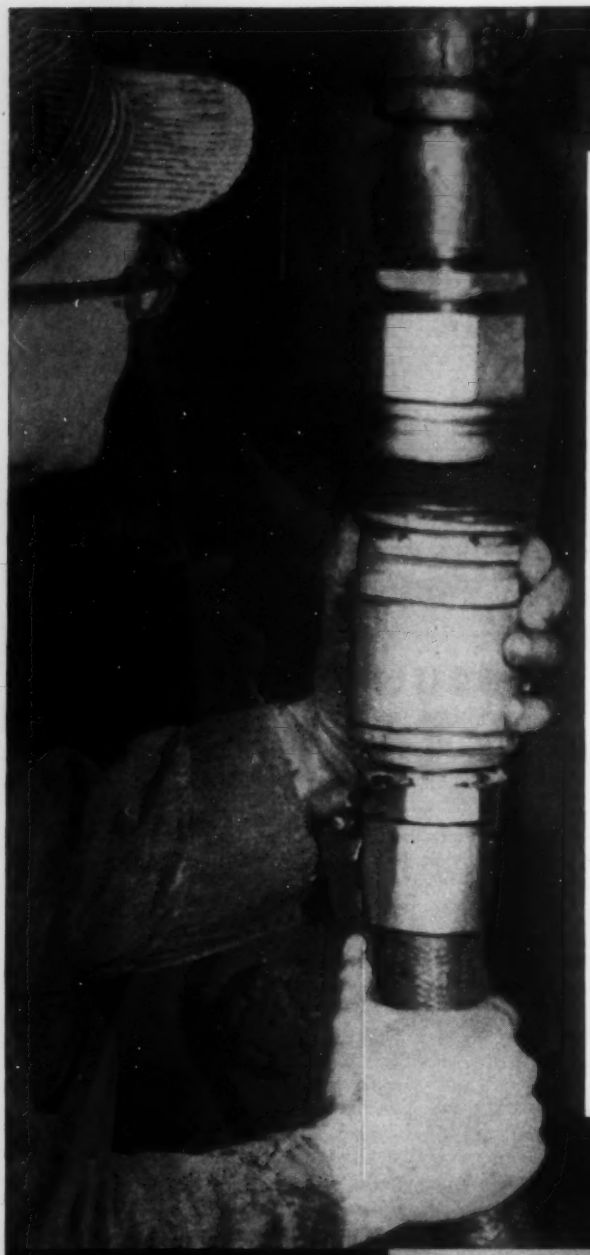
Please send me information on the all-new Copyflex Model 300.

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____



Now... Local Availability on

Titeflex

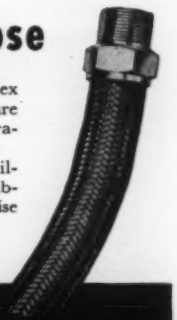
Seal-Tight, Time-Saving

Quick-Seal Couplings

Titeflex Couplings are *leakproof* at *all* operating pressures—the higher the pressure the tighter the seal! Couple or uncouple in ONE second... without the aid of tools. Straight-through or single or double check-valve types. Allow free flow of *any* viscous material. Sizes from ¼" to 12" diameter. Made from a variety of metals and alloys to suit innumerable industrial applications.

Titeflex

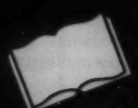
Flexible Metal Hose



—the ideal "conveying mate" for Titeflex Couplings. Withstands high temperature and pressure stresses. Impervious to vibration and corrosive action.

Both these time-tested products are available for immediate shipment from distributors' stocks in most areas. Otherwise write, wire or telephone direct.

CALL YOUR LOCAL DISTRIBUTOR



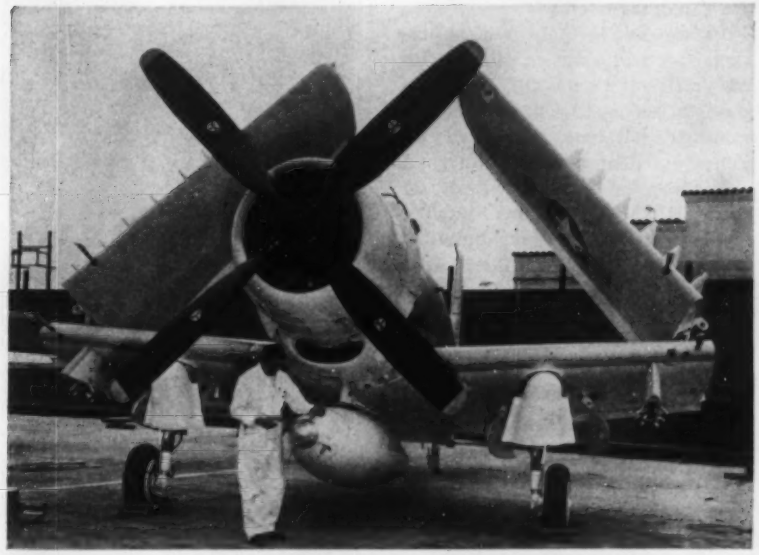
Consult the yellow pages of your telephone directory

Your one source for both Hose and Couplings

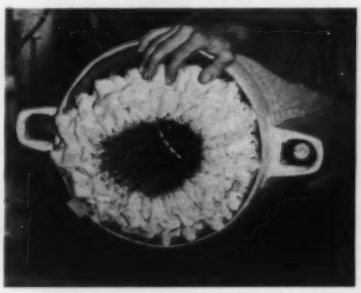
Titeflex

TITEFLEX, INC., 508 HENDEE STREET, SPRINGFIELD 4, MASS.

Circle 414 on page 19



QUICK CONVERSION of Navy fighters and attack bombers into aerial tankers will be possible with a self-contained refueling unit developed by Douglas Aircraft Co. Here the unit is shown mounted under an AD-7 Skyraider, the fleet's primary sustaining tanker. Jet model selected to carry extra fuel is the A4D Skyhawk. A contemplated use of the unit is on "buddy missions" in which two planes of the same type deploy together, the one refueling the other, then returning to base. The disposable unit is 17 ft long, powered by a ram-air turbine driven by its own four-bladed propeller. In addition to fuel, the unit carries hydraulic motors, fuel pump, a flexible hose on a reel and a collapsible drogue. The drogue is opened by a doughnut-shaped parachute.



kw nuclear power plants in three Latin-American nations. The first reactor export license was issued in connection with the sale of a research reactor to Japan.

Interference-fit thread, American Standard Class 5, is the subject of a tentative trial standard currently being circulated for criticism and comment. Sponsors are the American Society of Engineers and the Society of Automotive Engineers. The standard provides dimensional tables for external and internal interfence threads in the coarse-thread series from ¼-in. to 1½-in. diameter. Free copies are available from Frank Philippbar, Standards Dept., ASME, 29 West 39th St., New York 18, N. Y.

Designers, Foundrymen to See 1st Engineered Castings Show

Papers Planned for Concurrent 61st Castings Congress

CINCINNATI, O. — From May 6 to 10, exhibitors at the First Engineered Castings Show in the Cincinnati Music Hall will demonstrate the utility, quality and economy of castings in all fields of manufacture. Modern castings, patterns, testing devices and metals will be displayed.

At the same time and place, the 61st Castings Congress will be conducted. The Engineered Castings Show is expected to attract product design engineers from general industry as well as the thousands of foundrymen attending

load cells
based on the Statham unbonded strain gage transducer

For dynamic recording of forces during stress-strain determinations, breaking strength tests, ordinary load measurements and for indication or automated control.

TENSION-COMPRESSION
±10 to ±1,000 lbs.

COMPRESSION
0-10 to 0-1,000 lbs.

TENSION
0-10 to 0-1,000 lbs.

Please request Series L bulletins.

Statham
LABORATORIES
12401 W. Olympic Blvd., Los Angeles 64, Calif.

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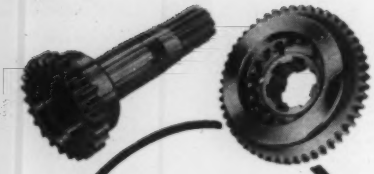


There is only ONE Best Gear Design for each application

. . . and SIER-BATH manufactures it into your gears

Sier-Bath serves you with the best gear design, engineering and manufacturing service. You get free engineering consultation and the finest gears to meet the increased requirements of tomorrow.

Sier-Bath designed and manufactured gears give you the same operating advantages that have brought leadership to many other machinery manufacturers.

No other gear company can now give you PRECISION CROWN-GROUND SPUR GEARS to 12" diameter, 4 pitch

Send us your gear prints or specs for study and quotation—or have a Sier-Bath gear specialist call to discuss the steps that will make us your ideal gear department.

Sier-Bath GEAR and PUMP CO., Inc.
9237 Hudson Blvd. North Bergen, N. J.
Established 1905 Member A.G.M.A.
Also Manufacturers of Screw and "Gearex" Rotary Pumps, and Flexible Gear Couplings

Sier-Bath PRECISION GEARS

All kinds of gears
—all materials
Made—cut—shaved—ground tooth
48" maximum diameter
12 or more of a kind, depending on size

Circle 416 on page 19

the Congress itself.

Papers to be delivered at the Congress will concern the casting materials—light metals, gray iron, steel, brass and bronze—malleable castings, patterns, industrial engineering, heat transfer and sand.

Sponsor for both Show and Congress is the American Foundrymen's Society. AFS headquarters are at Golf and Wolf Roads, Des Plaines, Ill.

Film-Recorded Enemy-Eye View Is Missile Evaluation Aid

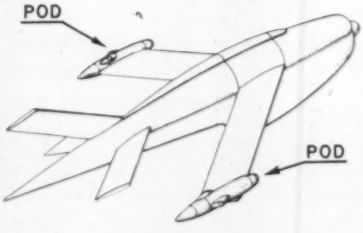
Cameras Ride Drone Target; Parachute After Direct Hit

CHICAGO, ILL.—Eight "eyes" on target drone aircraft now record the split-second sequence of events during missile-target encounters. The "eyes" prepare a record even in cases of direct hits which destroy the target itself.

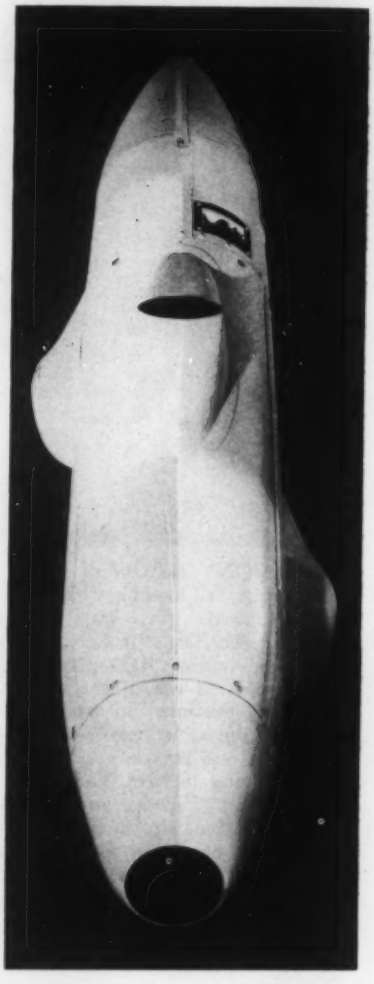
Four high-speed motion picture cameras in each of two pods at drone wing tips give spherical coverage around the drone regardless of maneuvers of either drone or missile. The "movie" record helps to evaluate missile performance.

The latest record system of this type uses 16-mm Bell & Howell cameras with 142-degree wide-angle lens. In each camera, 200 ft of film is exposed in 10-second bursts —enough to record four missile passes.

Actual scoring of missile behavior is done by orienting the film records on suitable grid co-ordinate charts. Data thus obtained show the missile trajectory, miss-distances, and other functional characteristics. Built into each camera is an electronic timing device which indicates on the film the time elapsed in fractions of a second.



"Eyes" in wing-tip pods give complete spherical coverage of missile engaging a target drone.



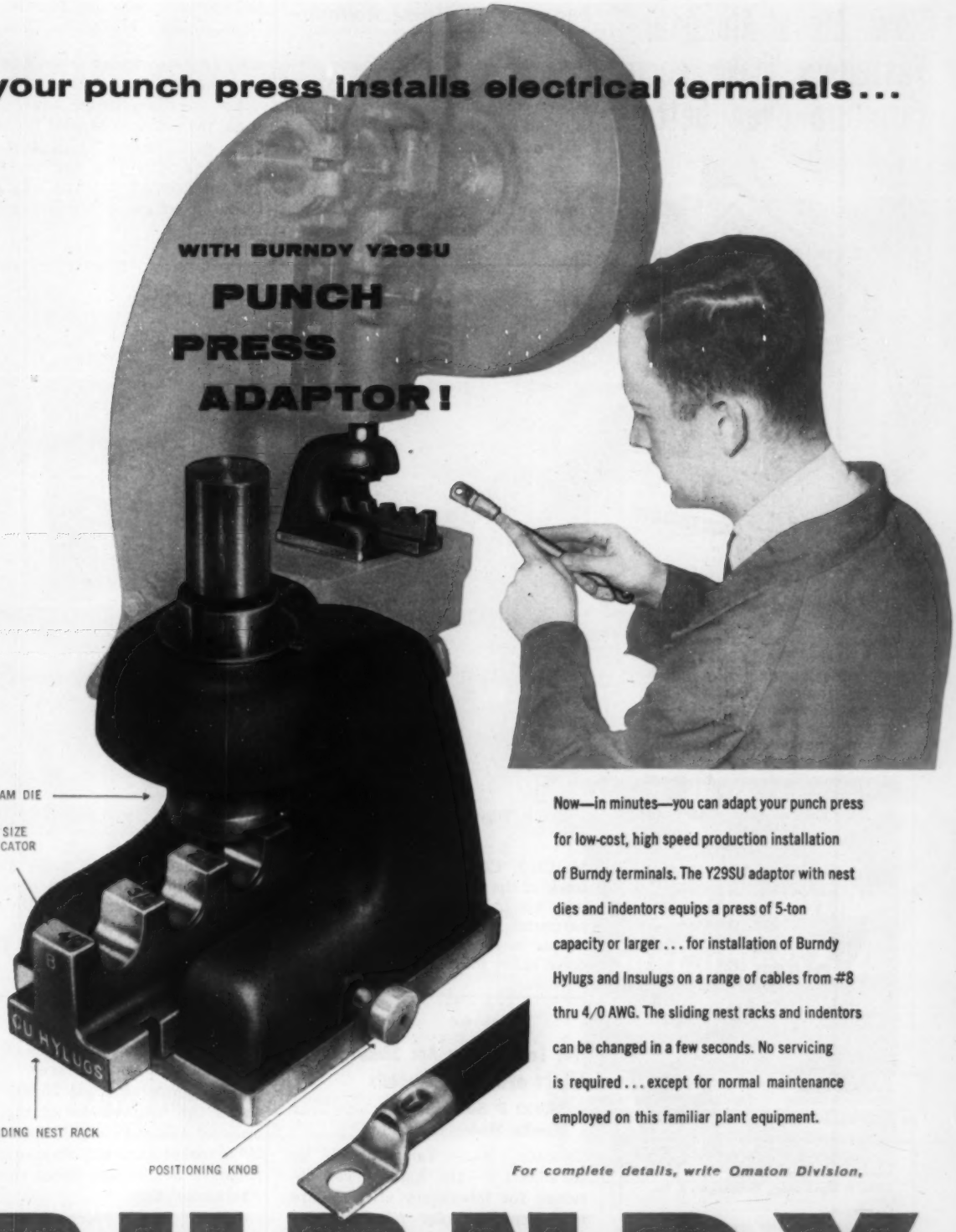
Missile-scoring pod for target drone wing tip carries four 16-mm cameras aimed so that approaching missile is always in view of one.

The system enables proper scoring at drone speeds up to Mach 0.95 and at altitudes from 5000 to 50,000 ft. Built-in-heating elements assure optimum camera performance at temperatures as low as −65 F.

Cameras are watertight and interchangeable. Operating speed is 200 frames per second; exposure time, 1/600 second per frame of film. High speed of the camera permits extreme slow-motion study of the projected film. For comparison, ordinary "slow-motion"

your punch press installs electrical terminals...

WITH BURNDY Y29SU PUNCH PRESS ADAPTOR!



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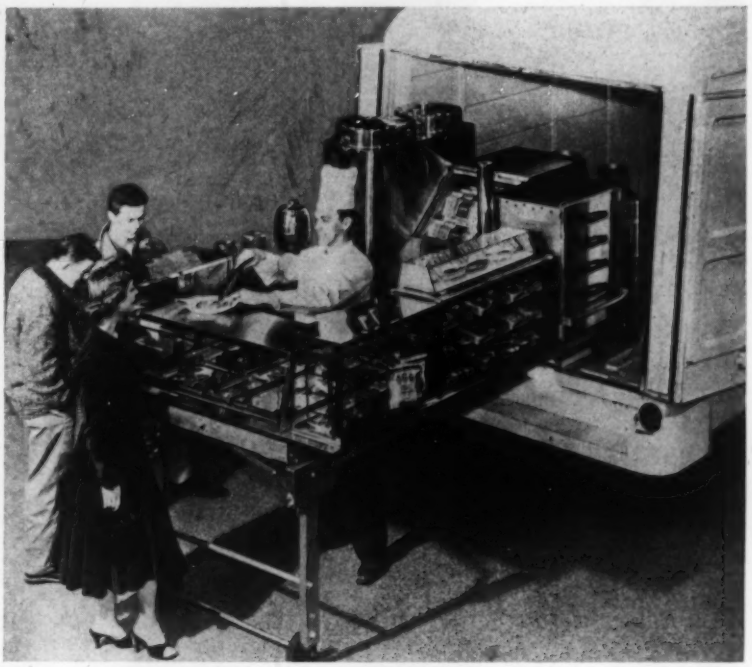
Circle 418 on page 19

movies are filmed at 64 frames per second.

Noteworthy is the pod's ability to bring back its photographic record under adverse conditions. If there is a direct hit, the pods are jettisoned without damage by means of an explosive bolt. Once free of the drone, the pods are lowered to earth by self-contained 16-ft parachutes.

For recovery from water, the pods have nonmechanical flotation gear which keeps them surfaced for 24 hr, built-in dye markers, and an exterior finish in standard recovery colors of brilliant yellow and red.



MOBILE CAFETERIA, one-man operated, slides out of a 1-ton Dodge truck at the touch of a button, is ready for serving in 40 seconds. Equipped with hot oven, steam table, coffee urns, refrigerator, pastry and candy compartments, the stainless steel Mobilteria can provide hot meals for 1000 people in less than 2 hr. The unit is 10 ft 7 in. long, 5½ ft wide. Chain drive slides unit in and out of truck, extends and retracts wheels.

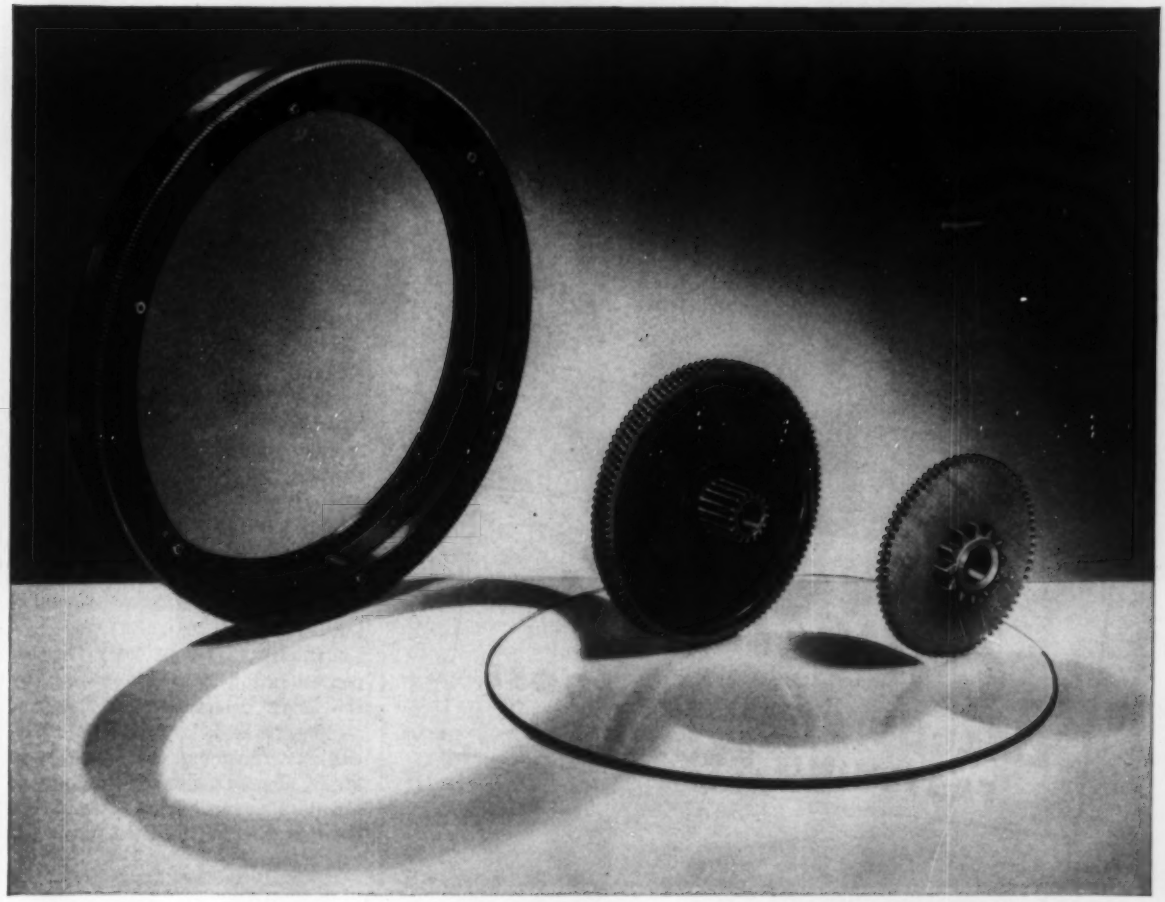
Hot Laboratory Arc Simulates Effect of Meteor Speeds

25,600 F Sustained for Missile Material Studies

CHICAGO, ILL. — Temperatures up to 25,600 F—the highest yet obtained for laboratory studies—are now generated for relatively extended periods of time by a jet of atomic vapor in a device called a water-stabilized electric arc. This is announced by the Chicago Midway Laboratories at the University of Chicago. Use of the new device should enable significant advances in the study of materials at extremely high temperatures.

The temperature of 25,600 F is twice the temperature at the surface of the sun; eight times that of a rocket exhaust; simulates the effect of 50,000 mph speed through the atmosphere.

Higher temperatures have been obtained in atomic explosions but only for fractions of a second. The vapor jet temperatures have been sustained as long as 3 minutes. Temperatures of the arc are determined by a spectrograph similar to that which measures the tem-



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Circle 419 on page 19

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BULLDOG BITE ENDS LOOSE FASTENING PROBLEMS!

Vibration can shake sales and profits apart in almost no time if the fasteners you use to assemble your products can't take it. Customer complaints, returns, or assembly rejects quickly pare profits to the vanishing point. Yet, actually, the problem of loose fastenings can be beaten, easily and at no increase in cost.

Everlock lock fasteners' exclusive chisel lock can't work loose. Once set, they stay that way! The chisel lock actually takes a better bite and tightens when subjected to vibration, jarring, impact or other product abuse.

Everlock lock fasteners are readily available in stock sizes and designs, or special designs, that end your particular loose fastening problems . . . *for good!* Call your nearest Everlock representative today for details.

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News Roundup

peratures of stars by their light.

Heat of the device comes from electricity arcing across the gap between two graphite electrodes, the lower one a rod and the upper one ring-shaped.

The temperature is intensified by a spinning cylinder of water that surrounds the arc. This wall of water confines the arc and concentrates its energy.

Some of the water vaporizes, feeding molecules of oxygen and hydrogen to the fiery stream of atomic vapor—"plasma"—that jets through the opening in the upper electrode. It is this super-heated jet of plasma into which metals and other materials are plunged for testing.

The power used in producing a temperature of 25,600 F, the highest thus far, is 8000 kw. Greater concentration of this power, say the arc's designers, can produce temperatures near 50,000 F. Plans call for replacing the water with liquid air, nitrogen, and helium to simulate conditions that would be encountered at different levels of the atmosphere.

Meetings
AND EXPOSITIONS

April 14-27—

First U. S. World Trade Fair to be held at the Coliseum, New York. Additional information is available from fair headquarters, 331 Madison Ave., New York 17, N. Y.

April 23-24—

American Institute of Electrical Engineers. Third Biennial Conference on Electric Heating to be held at the Commodore Perry Hotel, Toledo, O. Additional information is available from institute headquarters, 33 W. 39th St., New York 18, N. Y.

April 24-25—

National Industrial Research Conference to be held at the Conrad Hilton Hotel, Chicago. Sponsor is Illinois Institute of Technology; further information is available

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from Raymond D. Meade, Conference Co-ordinator, Illinois Institute of Technology, 3300 S. Federal St., Chicago 16, Ill.

April 25-26—

American Society of Mechanical Engineers—Society for the Advancement of Management. Management Conference to be held at the Statler Hotel, New York. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

April 25-26—

American Zinc Institute Inc. 39th Annual Meeting to be held at the Drake Hotel, Chicago. Further information is available from institute headquarters, 60 E. 42nd St., New York 17, N. Y.

April 25-26—

Institute of Environmental Engineers. Annual Technical Meeting to be held at the LaSalle Ho-

"I don't like it."

tel, Chicago. Further information is available from Henry F. Sander, Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

April 30-May 1—

Metal Powder Association. 13th Annual Meeting and 1957 Metal Powder Show to be held at the Drake Hotel, Chicago. Further information is available from association headquarters, 130 W. 42nd St., New York 36, N. Y.

May 1-3—

Electronic Components Conference to be held at the Hotel Mor-

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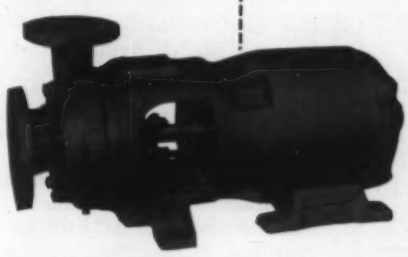

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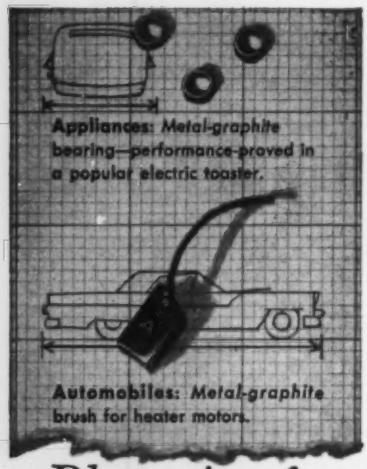
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Circle 422 on page 19

rison, Chicago. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Radio-Electronics-Television Manufacturers Association. Additional information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

May 1-3—

Society for Experimental Stress Analysis. 1957 Spring Meeting and Exhibit to be held at Hotel Statler, Boston. Further information can be obtained from SESA headquarters, P. O. Box 168, Cambridge 39, Mass.

May 6-10—

Industrial Tool and Production Show of Canada to be held in the Industry Bldg., Exhibition Park, Toronto. Additional information can be obtained from show headquarters, 19 Melinda St., Toronto, Ont., Canada.

May 6-10—

American Foundrymen's Society. 61st Annual Castings Congress and First Engineered Castings Show to be held at the Music Hall, Cincinnati. Further information is available from society headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 13-15 —

National Conference on Aeronautical Electronics to be held in Dayton, O. Sponsor is the Institute of Radio Engineers. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

May 14-16—

Second Annual Industrial Nuclear Technology Conference to be held at the Museum of Science and Industry, Chicago. More information can be obtained from Dr. Leonard Reiffel, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

May 15-17—

Radio - Electronics - Television Manufacturers Association. Annual Meeting to be held at the Sheraton Hotel, Chicago. Additional information is available from association headquarters, 1721 De Sales St. N. W., Washington 6, D. C.

May 19-23—

American Society of Mechanical Engineers. Oil and Gas Power Conference to be held at the Kentucky Hotel, Louisville. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 20-21—

Eighth Annual Appliance Technical Conference to be held in the Engineering Societies Bldg., Detroit. Conference is sponsored by the Subcommittee on Domestic Appliances of the American Institute of Electrical Engineers. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

May 20-23—

Design Engineering Show to be held at the Coliseum, New York. Second Annual Design Conference, to be held in conjunction with the show, is sponsored by the Machine Design Div. of ASME. Further information on the show is available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 22-23—

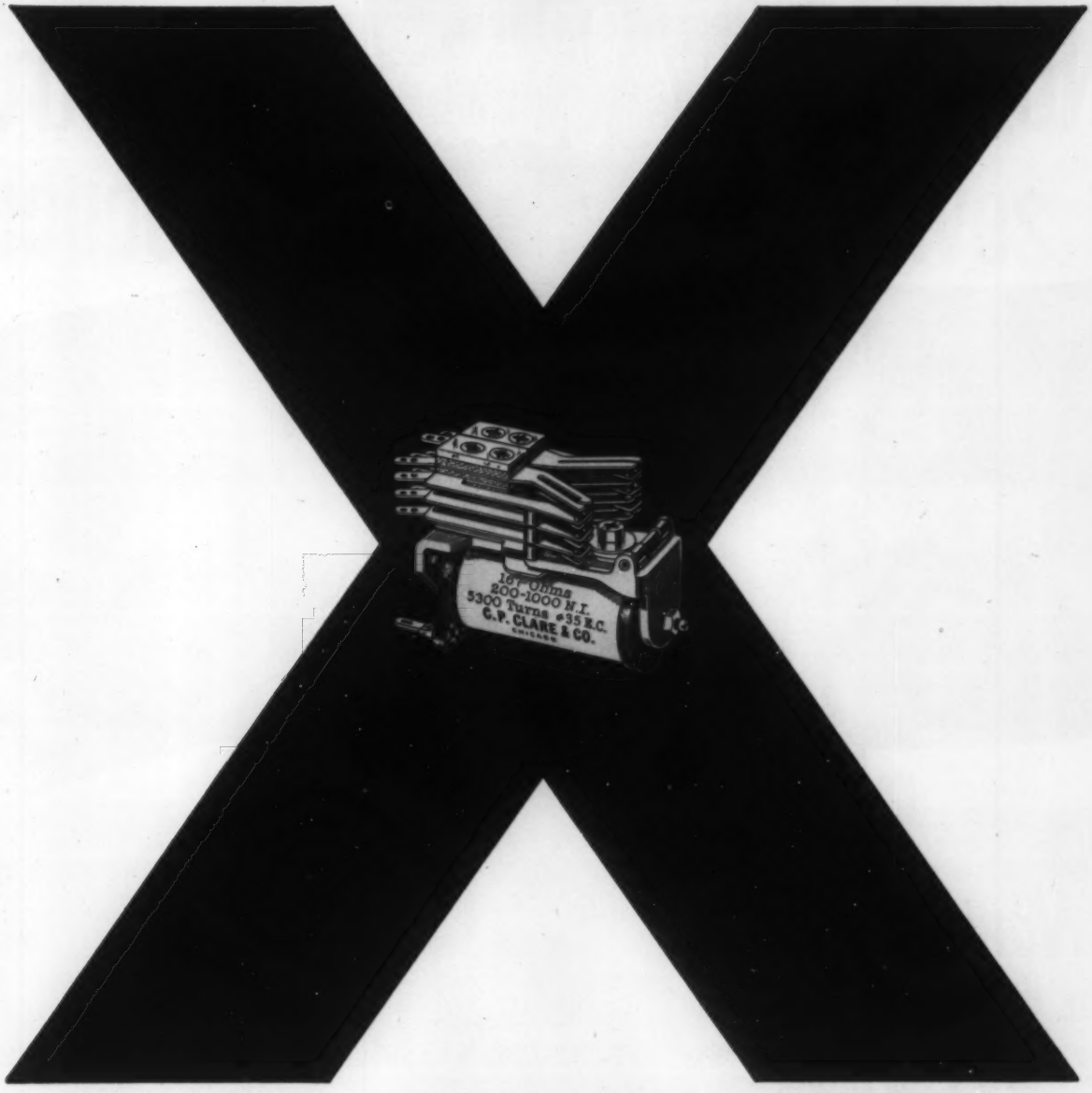
American Iron and Steel Institute. Annual Meeting to be held at the Waldorf-Astoria Hotel, New York. Additional information can be obtained from institute headquarters, 350 Fifth Ave., New York 1, N. Y.

May 22-24—

American Society for Quality Control. 11th Annual Convention to be held in the Masonic Temple, Detroit. Further information is available from R. V. Ward, Canadian Industries Ltd., P. O. Box 10, Montreal, P. Q., Canada.

Oct. 14-15—

Fourth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.



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Circle 423 on page 19

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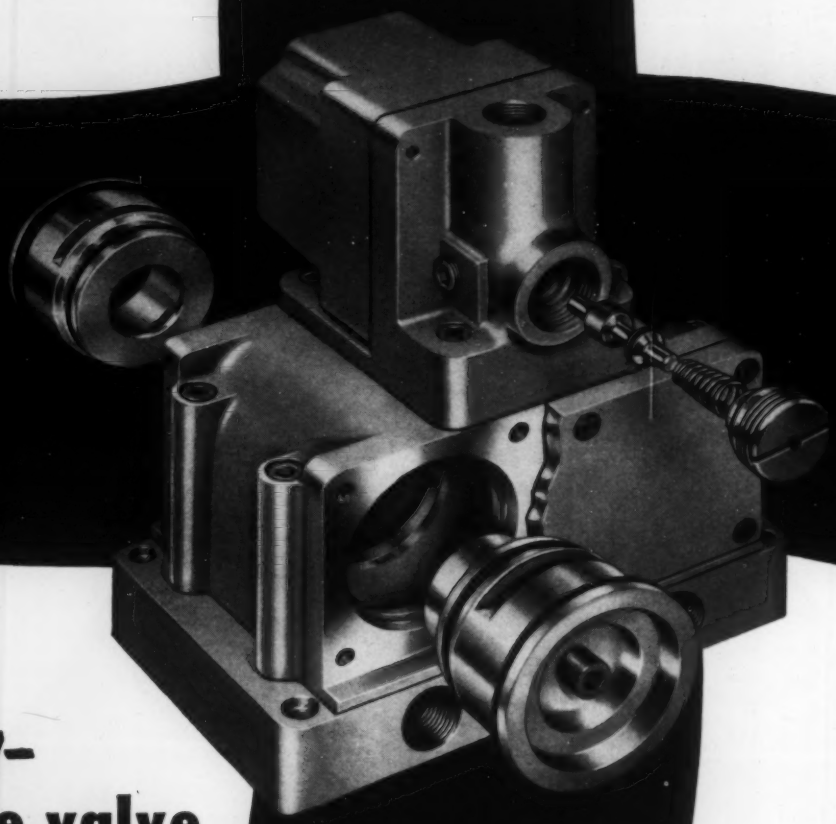

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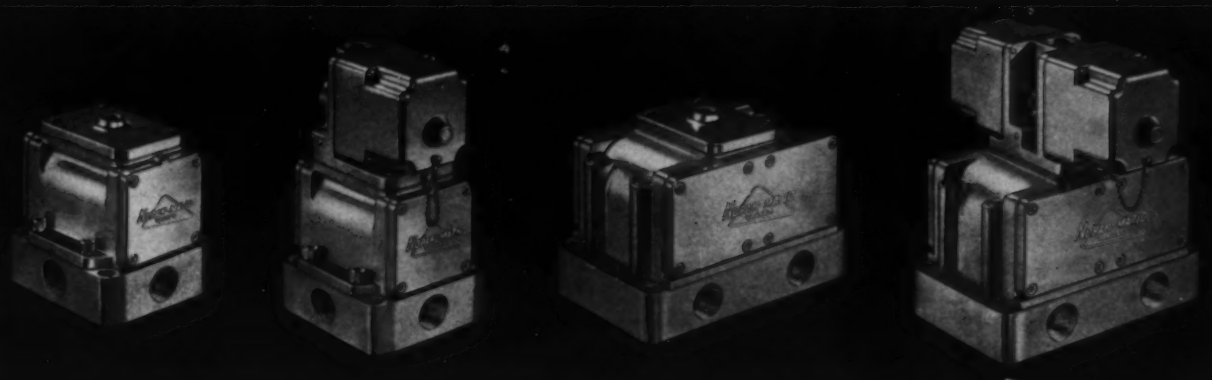

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CATALOG NO. 105 — describes and illustrates all the Nopak-matic Plus Valves and gives complete dimension, installation and parts data. Write for catalog 105 now. It will be mailed promptly.

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Circle 424 on page 19

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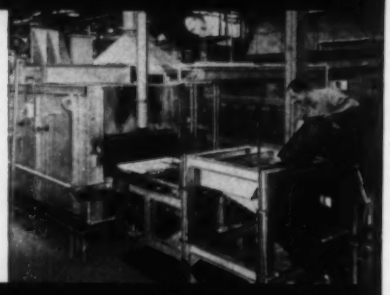

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Circle 425 on page 19

Circle 426 on page 19→

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 37

Heat Resistant Silicone Enamel Improves Space Heater, Cuts Costs

Paints and enamels made with Dow Corning Silicones not only solve the problem of keeping an attractive finish on hot metal surfaces, but frequently effect noteworthy savings in production costs as well. For example—

Five years ago, Temco, Inc., Nashville, Tenn., switched from a vitreous finish to a silicone enamel for the upper grille of their gas-fired wall heaters. The heater normally operates at 350 F, but a blocked flue can quickly boost this temperature to 500 F. Temco has used the silicone enamel on over 25,000 units without a single customer complaint about loss in color, gloss or adhesion.

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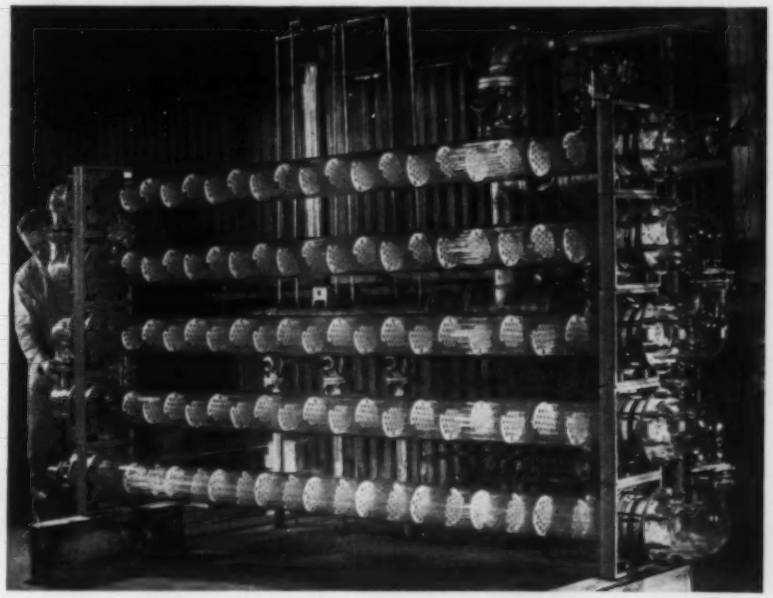

Silastic Seals Help Make Glass Heat Exchangers Maintenance-Free

With superior resistance to heat and compression set, Silastic* — the Dow Corning silicone rubber — has helped Corning Glass Works to engineer low maintenance into their new Pyrex modular shell-and-tube heat exchanger.

Mass produced for off-the-shelf delivery, these glass heat exchangers are designed for processing corrosive and metal-sensitive liquids. Any number of standard sections can be combined into a single, efficient heat exchange unit. Maintenance is almost nil due to the glass construction and the efficiency of a Silastic seal between the shell and tube.

Here's how it works: a resilient Silastic gasket is put under pressure by tightening the flange bolts of the sections. Completely contained between the tubes and a retainer ring, the Silastic in turn, forces a Teflon "protector" sheet to form a permanent, leakproof seal against the tube ends. Resilience and positive pressure are maintained by the Silastic part despite expansion and contraction at operating temperatures as high as 375 F.

*T.M. REG. U. S. PAT. OFF.

(Cont. Pg. 2)

Silicones Assure Top Performance of Mercury Outboard Motors

New evidence to the versatility of Dow Corning silicone compounds comes from Kiekhaefer Corp., Fond du Lac, Wisconsin, manufacturer of the "Mark 75," world's most powerful production outboard motor.

To help keep this and the other eleven new Mercury motors in top operating condition despite rugged service, Kiekhaefer coats several rubber, ceramic and metal parts in every motor with a paste-like silicone dielectric compound. Exceptionally resistant to heat, cold, oxidation and moisture, the silicone compound protects and preserves rubber, serves as a light lubricant, and helps prevent shorts in the electrical system. Since this Dow Corning silicone compound remains serviceable from —70 to 400 F, it stays in place under adverse conditions to minimize maintenance and to assure long, trouble-free service. *No. 376*

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .

Shell Molding with silicone parting agents is described in a new, illustrated "how-to-do-it" brochure. Included are recommendations for cleaning and breaking-in patterns, and suggestions for getting continuous, easy release of shell molds with high dimensional accuracy. *No. 380*

Silicone Materials in Appliance Design, a recent article in ELECTRICAL MANUFACTURING, lists a variety of applications for several different silicones in appliances; describes how silicones have made possible design changes heretofore impractical, and how they extend service life and dependability. To receive your copy, circle *No. 381*

Silicone Coatings for Metal Products. An article reprint from MATERIALS AND METHODS provides a comprehensive review of current uses for all types of silicone finishes now available. Includes information on coverage, costs, and methods of application. A valuable aid in selecting the most suitable type of silicone finish for any particular application. *No. 382*

Silicone Shoes for Brakes, reprinted from PRODUCT ENGINEERING, tells how the B. F. Goodrich Company solved a critical problem in aircraft brake design by using braking shoes molded from Dow Corning 301 Molding Compound. 301 Compound was selected because it will withstand the intense heat — up to 1500 F developed at the brake lining surface. *No. 383*

Silicone News Comes Alive—at Design Engineering Show, May 20 to 23. Make a note now to visit Booth 406 on the first floor of the New York Coliseum on these dates. See silicones at work in a wide variety of design applications. Meet our technical representatives and discuss how silicones can help solve some of your design problems. *No. 384*

Engineering brochure on Silastic 50 and 80; includes detailed information on these two general purpose silicone rubbers; provides a convenient reference for design and production engineers. *No. 385*

Protect Current Transformer With Silastic Encapsulation

Encapsulation in Silastic*, Dow Corning's silicone rubber, has proved to be an ideal solution to the problem of protecting electrical and electronic components from vibration, heat, moisture and corrosive conditions. An excellent example is found in the new Type 5-kv current transformer made by Westinghouse.

A highly compact unit designed for indoor metering or relaying applications, the SM-5 transformer is the smallest, lightest and most durable 5-kv unit ever built. Silicone insulated throughout, the SM-5 easily meets all ASA and NEMA standards.

To further assure top dependability, the entire core-coil assembly is encapsulated in an attractive, one-piece silicone rubber jacket. This jacket remains resilient and retains its original dielectric properties even in locations subject to extreme changes in temperature and humidity. The silicone rubber also expands and contracts with the coil. As Westinghouse aptly describes it, "transformer performance is sealed in to stay." *T. M. REG. U. S. PAT. OFF. *No. 377*

SILICONE ENAMEL *(Cont.)*

Because the silicone coating remains flexible and does not require high-temperature firing, production savings have been tremendous. Rejects due to chipping and warping have been virtually eliminated. Even handling and shipping costs have been reduced.

The enamel used in this application is a brown Sicon finish formulated with Dow Corning Silicones by Midland Industrial Finishes Company. A single coating is sprayed on the steel grille and baked for 20 minutes at 350 F. *No. 378*

SILASTIC SEALS *(Cont.)*

That's the kind of serviceability you can expect from seals backed by these typical Silastic properties:

• Temperature range, F	—130 to 500
• Tensile strength, psi	600 to 900
• Elongation, %	150 to 300
• Tear strength, lb/in	40 to 75
• Compression set, %, at 300 F	25 to 50
• Hardness range, Durometer	20 to 80
• Weather, ozone and corona resistance	Excellent

No. 379

CLASS H MOTOR STILL ON TEST AFTER 62,672 HOURS AT 240 C

At 10 A. M., June 3, 1946, a Class H insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since the test began, the motor has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A.M. March 1, 1957, this motor was still on test after 62,672 hours at an average copper temperature of 240 C! That's equivalent to 383 years operation at the Class H temperature of 180 C.

Most electrical equipment manufacturers offer silicone (Class H) insulation in new equipment. Over 200 leading motor repair shops offer silicone rewinds for motors, generators and transformers at little or no premium over Class B insulation.

Dow Corning Corporation, Dept. 6816, Midland, Michigan

Please send me: 376 377 378 379 380 381 382 383 384 385

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COMPANY _____

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SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION
MIDLAND MICHIGAN

first in silicones

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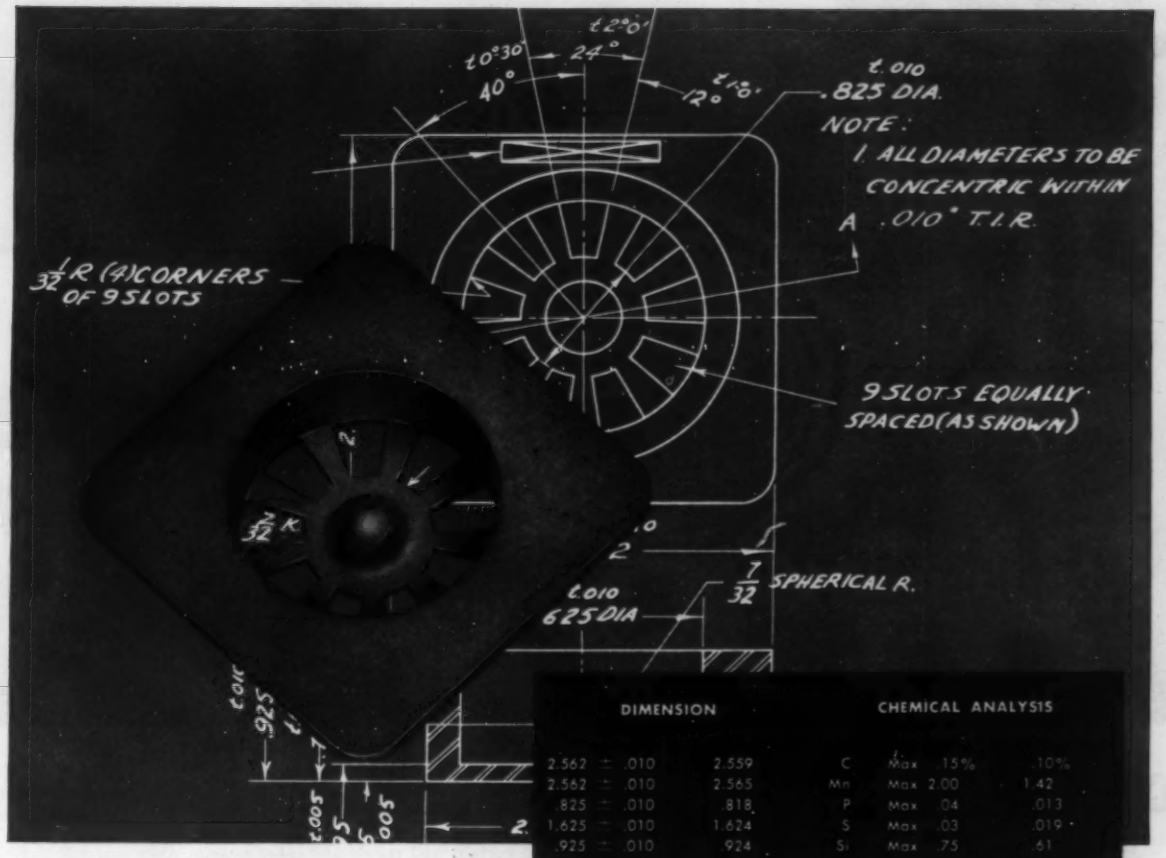


DIMENSION			CHEMICAL ANALYSIS		
2.562 ± .010		2.559	C	Max .15%	.10%
2.562 ± .010		2.565	Mn	Max 2.00	1.42
.825 ± .010		.818	P	Max .04	.013
1.625 ± .010		1.624	S	Max .03	.019
.925 ± .010		.924	Si	Max .75	.61
.700 ± .010		.698	Ni	12.00-14.00	13.00
.105 ± .005		.109	Cr	16.00-18.00	17.70
2.050 ± .010		2.058	Cu	Max .50	.07
.295 ± .005		.293	Mo	1.50-2.25	1.96

Rely on

Crucible ACCUMET investment castings

for dimensional and metallurgical accuracy . . .

This intricately shaped aircraft instrument part had to be held to rigid specifications both in size and in chemical analysis of the steel.

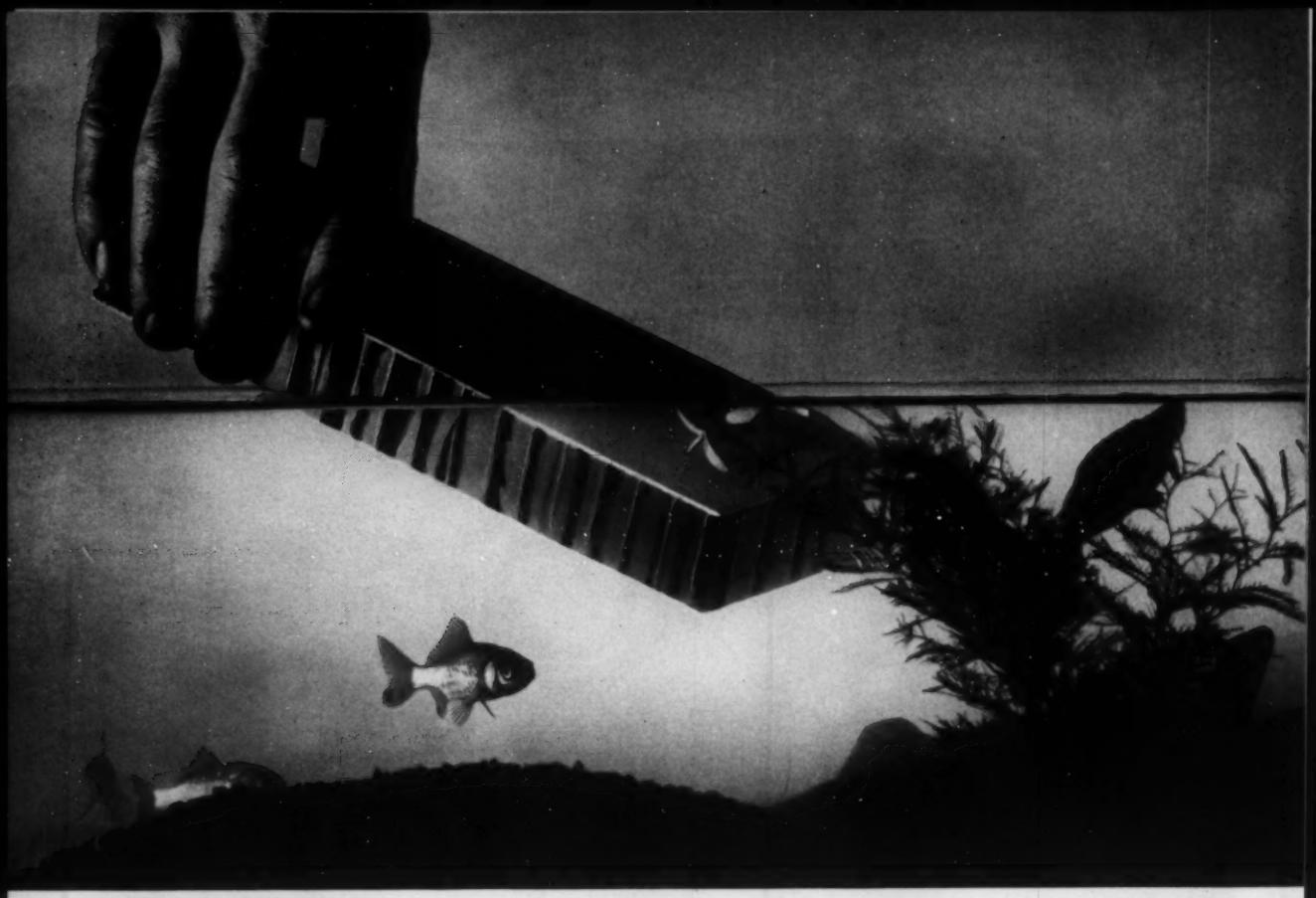
That's why Crucible ACCUMET® precision castings were used. For Crucible's *lost wax* method of casting, and its long experience as the country's leading producer of fine special purpose steels, combine to bring you accurate castings of the highest quality. But the two tables shown below actually tell the story better than words can. They show how closely ACCUMET castings are held to original specifications.

The next time you have a job where quality and close tolerances are needed, be sure to investigate the advantages of ACCUMET precision castings. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

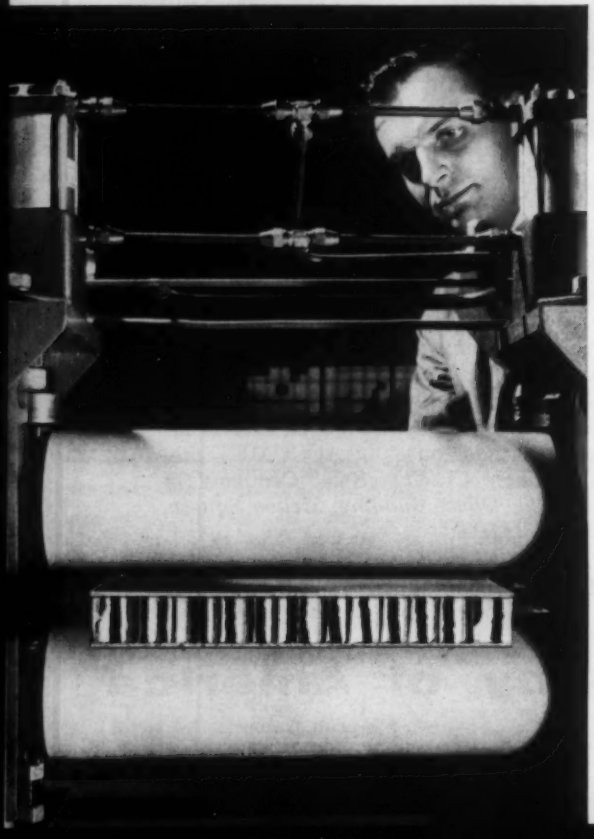
Crucible Steel Company of America

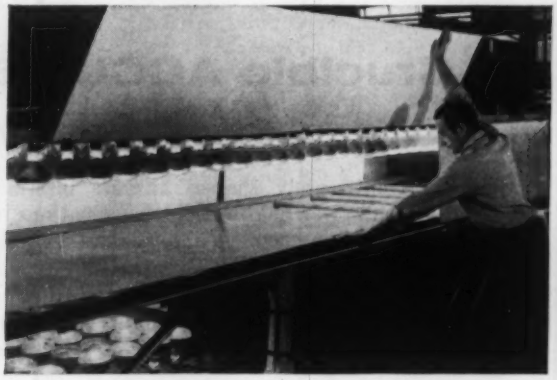
Circle 427 on page 19



EC-1357 for non-load-bearing uses

Even under water EC-1357 continues fastening sandwich components securely. Moisture won't hurt this tough 3M adhesive bond. Neither will normal indoor and outdoor temperatures. The curtain wall panels and other exterior units you fabricate with EC-1357 ruggedly resist weather and exposure.



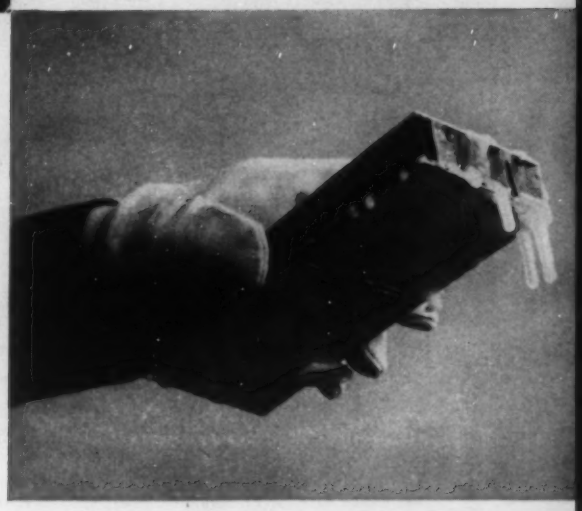


You can force-dry EC-1357 to get maximum immediate bonding strength fast. The adhesive grips skins and cores firmly together as production proceeds. You eliminate expensive drying and storage time. You gain continuous material movement from adhesive spraying to finished sandwiches. And EC-1357 builds up even more strength with age as it cures at room temperatures.

Nip roller or cold press is all you need to complete EC-1357 bonds. Whether you force-dry the adhesive or not, you can fabricate durable, high-strength sandwiches without clamps or heated presses.

EC-1177
for load-bearing uses

Rugged load-bearing ability of EC-1177 is proven by laboratory tests and experience both. In this adhesive, 3M research has combined high strength with rigidity under stress. You gain a heavy-duty bond that answers load-bearing sandwich demands.



Intense cold and heat don't faze EC-1177. It goes on bonding strongly despite severe temperatures. With EC-1177 you build high-temperature resistance right into load-bearing sandwich structures.

Beef up sandwich structures with these high-strength 3M adhesives

Put top strength into your sandwich structures right where it counts most . . . in the skin-to-core bonds.

You can with EC-1357 and EC-1177. These 3M adhesives are helping make sandwich construction the featherweight performance champ of a hundred industries.

- Flexible EC-1357 bonds lightweight skins and cores together into tough, resilient structures for non-load-bearing uses. And it goes on bonding securely despite moisture, heat, cold and exposure.

Here's durability that's vital in curtain wall panels, movable partitions and compartment separators.

What's more, EC-1357 speeds production. You can force-dry this 3M adhesive, get high bonding strength fast. Dark in color, it absorbs drying heat rapidly. With or without force-drying, you can bond sprayed surfaces cold, with just a nip roller or cold press.

- EC-1177 delivers the ruggedness your structures need to carry loads . . . high strength, rigidity under stress, great heat and cold resistance. Designers specify EC-1177 for aircraft walkways, trailer roofs and floors, platforms, shelves, tables and load-bearing partitions.

Compared to mechanical fastening, both EC-1357 and EC-1177 cut down heat transfer through panels. They reduce your risk of fracturing cores, too.

Whether you use steel, porcelainized steel, aluminum, anodized aluminum, bronze or hardboard skins . . . whether you use resin-impregnated paper, aluminum or stainless steel honeycomb cores, or cores of wood, fibrous glass or expanded cellular glass . . . investigate EC-1357 and EC-1177.

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Full facts on EC-1357 and EC-1177 are yours for the asking. Fill out and mail the handy coupon today. Or write on your business letterhead to the address at the right. 3M Research and 3M Field Engineers are ready to serve you.

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Send me free literature on 3M Sandwich Construction Adhesives EC-1357 and EC-1177. Please (do) (do not) have a 3M Field Engineer contact me at this time.

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WAGNER ELECTRIC MOTORS . . . THE CHOICE OF LEADERS IN INDUSTRY

smaller, lighter fractional horsepower motor solves problems for the design engineer

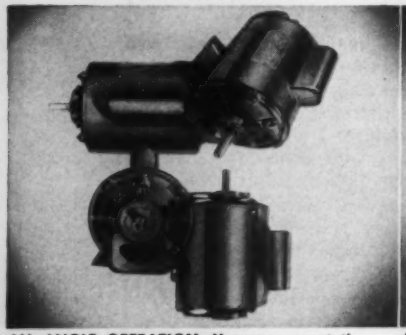
Type RK, Capacitor-start, ⅛, or ¼ hp.

the WAGNER "48"

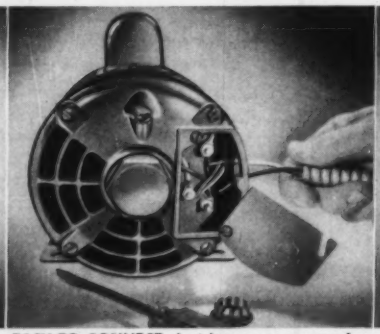
Here's the 48 frame motor you've been looking for! The Wagner "48" capacitor-start motor with either resilient or welded rigid base. You get the standard 48 frame size, with from *three to eight pounds less weight per motor* than previous models of the same hp ratings!

The Wagner "48" is rugged enough to permit direct mounting, compact enough to fit in tight spots, will operate efficiently when mounted at any angle. Through ventilation assures cool operation that adds to motor life.

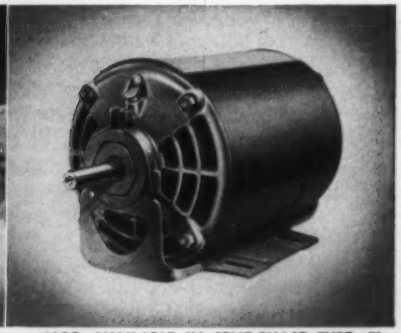
If you would like to test the Wagner "48", one of our field engineers will be glad to furnish a sample motor. Contact the Wagner Branch near you or write to the factory.



ALL ANGLE OPERATION. You can mount the Wagner "48" at any angle. A new lubrication system assures positive protective lubrication in any position.



EASY TO CONNECT. Just loosen one screw for access to terminal board. EASY TO SERVICE . . . no need to disconnect leads when removing endplates.



ALSO AVAILABLE IN SPLIT-PHASE TYPE. The Wagner "48" is also furnished in split-phase type, with resilient or rigid base in ratings of ⅛, ¼ and ⅓ hp.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

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STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern styling

Clean lines. A crisp, new look. More functional. Lasting beauty. These are some of the effects modern designers gain with stainless steel—why they use more and more stainless steel every year in cars as well as appliances, housewares, furniture and houses.

To marketers, stainless steel combines the smart selling values of beauty and easy maintenance with the hard selling values of superior corrosion resistance, durability and toughness.

Stainless steel is available in countless work-saving standard shapes. It's readily machined, formed, joined, or cast.

For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

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30 E. 42nd Street UCC New York 17, N.Y.

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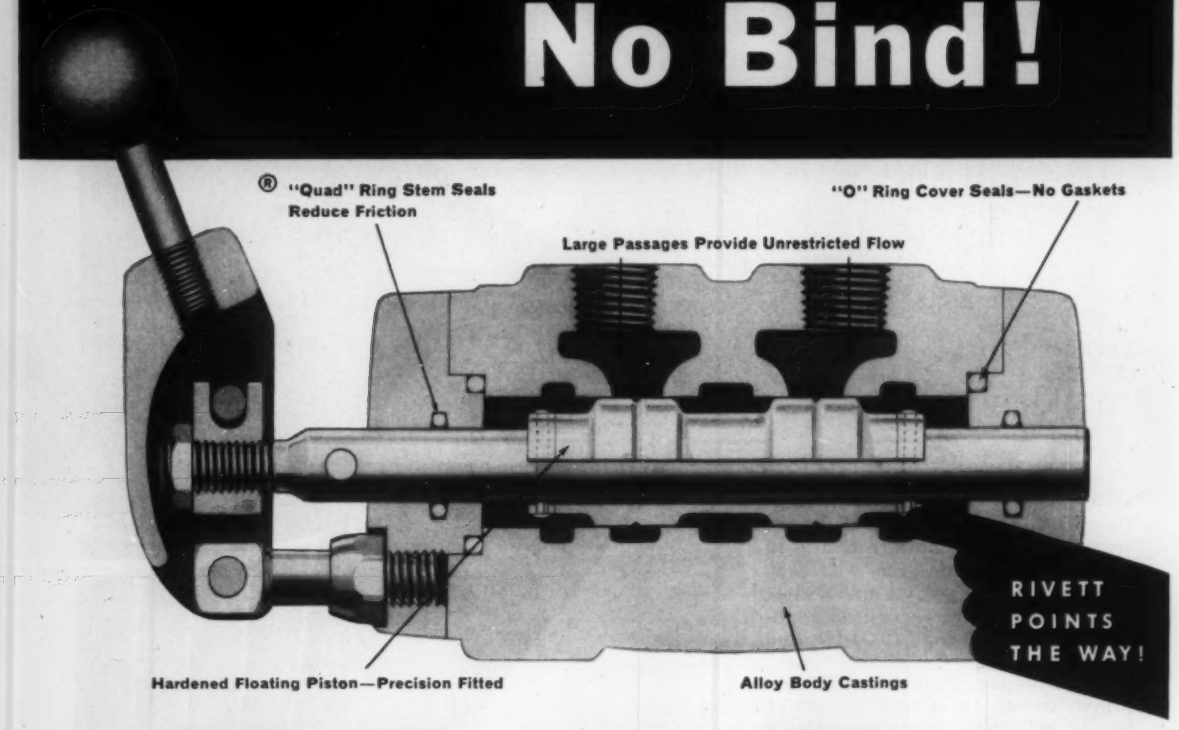
Stainless steel styling ... first to catch the eye and quickest to capture the heart of the consumer. It combines beauty with hardness and strength to resist denting and scratching—and rust is never a problem.

Circle 430 on page 19

No Stick! No Bind!


® "Quad" Ring Stem Seals Reduce Friction
"O" Ring Cover Seals—No Gaskets
Large Passages Provide Unrestricted Flow
RIVETT POINTS THE WAY!
Hardened Floating Piston—Precision Fitted
Alloy Body Castings

-with Floating Piston!

Valve Stem is Independent of Valve Bore in Rivett Hydraulic Pipe Mounted Valves

Other Fine Features Benefiting Your Circuit Design and Operation

- "Quad" Ring Stem Seals Reduce Friction
- Large Passages Provide Smooth, Full Capacity Flow
- Simple Design Assures Leakproof Operation
- Opens And Closes Smoothly, Positively
- Operates Multi-Million Cycles At 1500 P. S. I.

1607 VALVE SELECTIONS!

Types: Hand, foot, cam, solenoid, pilot, oil pressure, air pressure, flow control, check, deceleration, relief, unloading, sequence, counterbalance.

Sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½".

Actions: Standard, spring-return, spring-centered, ball detent.

Mountings: Pipe mounted; panel mounted.

P.S.I.: 1500 P.S.I.; 3000 P.S.I. oil service.

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THE BETTER YOU KNOW HYDRAULICS THE BETTER YOU LIKE

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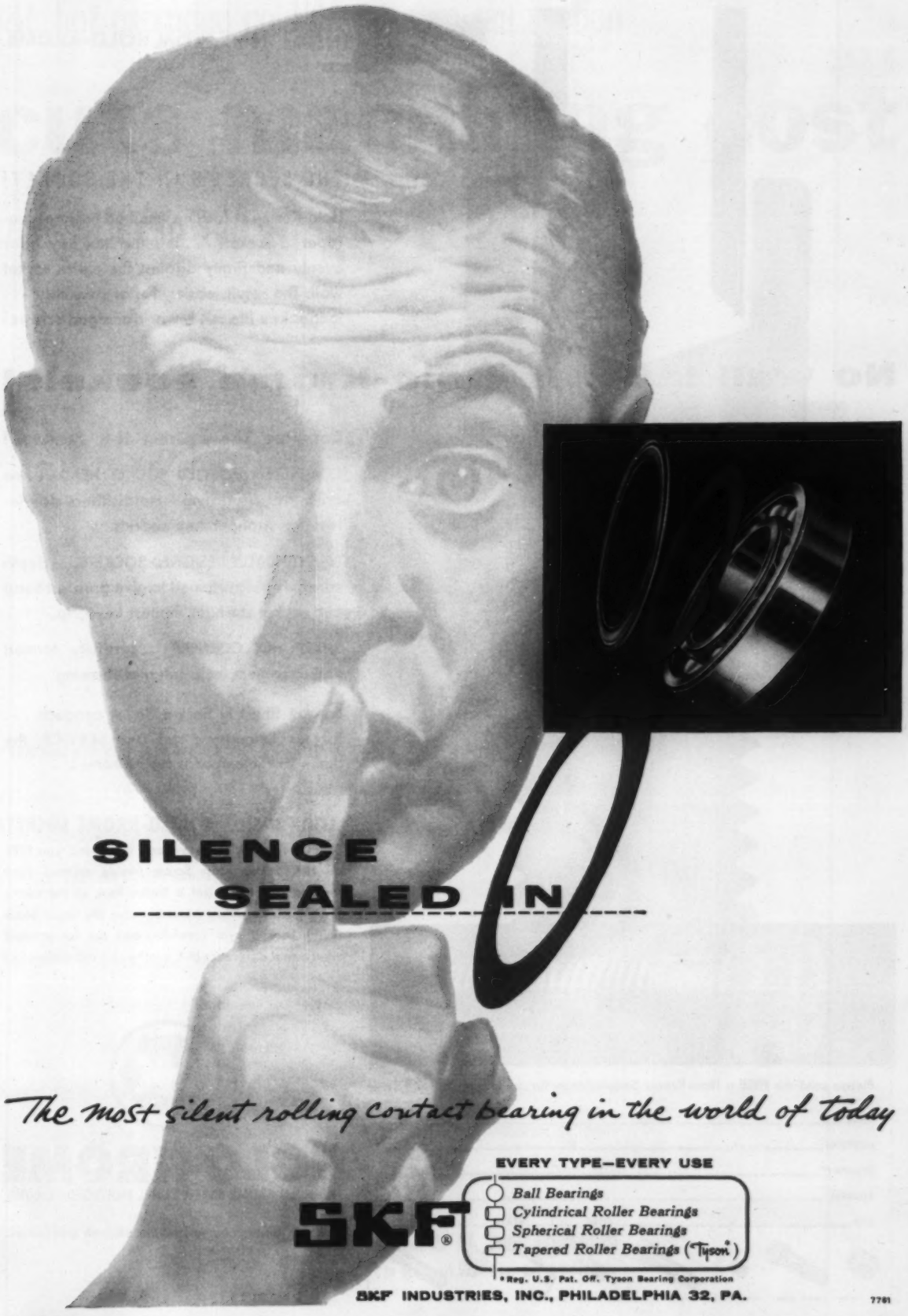
RIVETT
"100"
HYDRAULIC VALVES

Circle 431 on page 19



The most silent rolling contact bearing in the world of today

EVERY TYPE—EVERY USE

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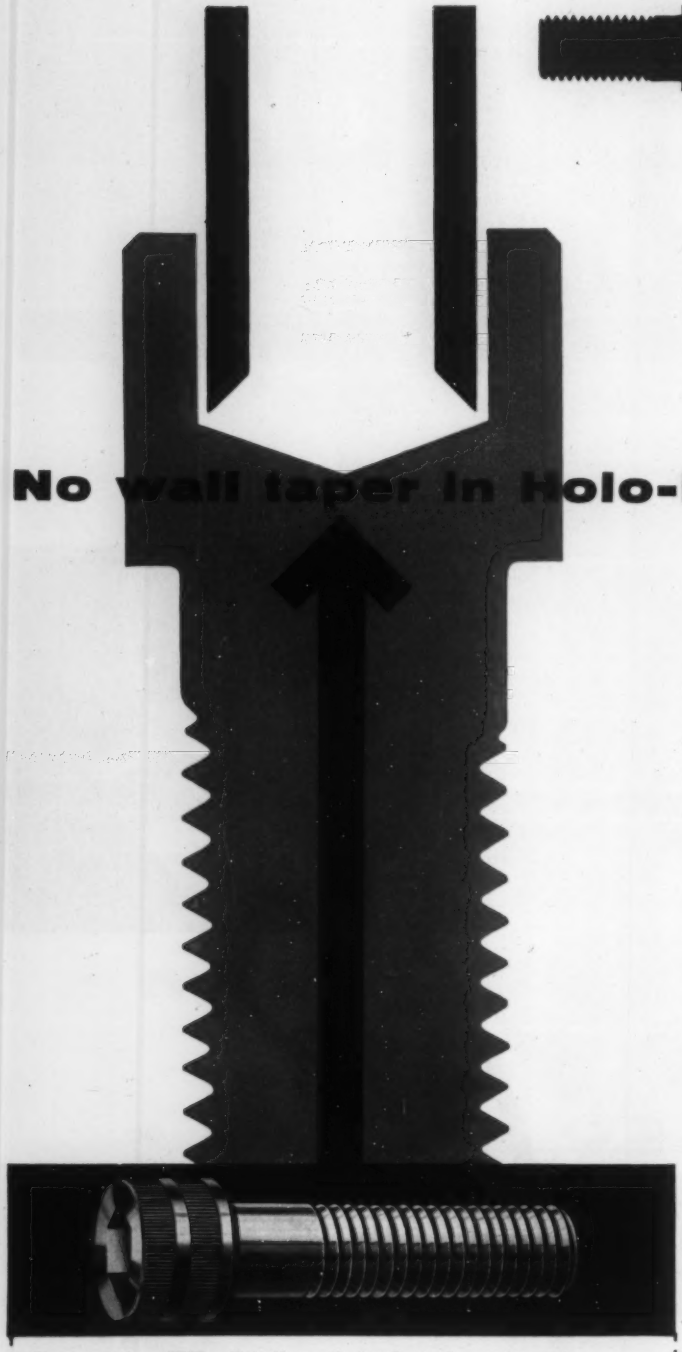
INSIDE INFO FROM HOLO-KROME



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Holo-Krome's forging method assures untapered sockets . . . lets the hex key bear evenly and firmly against the entire socket wall. The result: easier, faster assembly . . . longer key life . . . fewer damaged screws!

No wall taper in Holo-Krome sockets!

Compare These Other H-K Features!

COMPLETELY FORGED SOCKET HEAD . . . no drilling or broaching—metal fibers stay intact for stronger hex sockets.

SCIENTIFICALLY DESIGNED SOCKETS . . . depth carefully proportioned to give greatest head and socket strength, firmest key grip.

SHARP HEX CORNERS . . . carefully formed socket corners resist internal reaming.

For the finest in Socket Screw products . . . for revolutionary SAME-DAY SERVICE, the name to remember is Holo-Krome!

LOOK INSIDE A HOLO-KROME SOCKET!

Send in the coupon below and we'll send you FREE an H-K Socket Cap Screw (we've omitted heat treating to let you get a better look at the mirror finish and sharp hex corners under the usual black finish). Look it over carefully, and see for yourself what a real difference H-K quality and skill can make!

Please send me FREE a Holo-Krome Socket Screw for my inspection.

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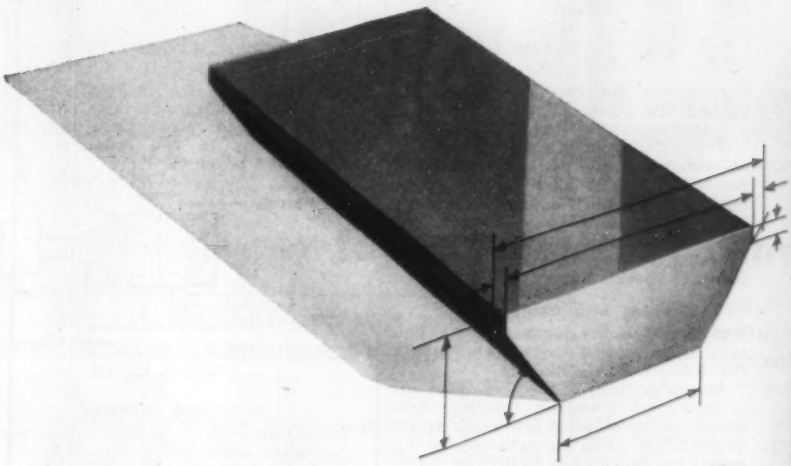
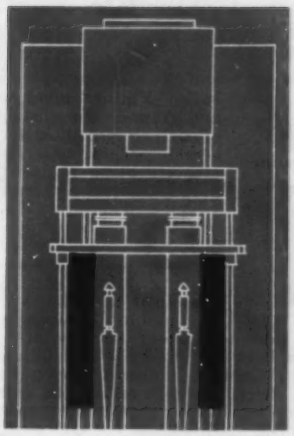
Sold only through authorized Holo-Krome distributors.

J&L hot extruded cold drawn cam rail section

cuts machining cost

from $1.75 to 75¢ per foot





"This part was previously milled from a cold rolled section at a cost of approximately $1.75 per running foot. Our present cost is 75¢ per foot using your cold drawn extruded section." This machine tool manufacturer cut his production costs by buying these exclusive J&L steel sections. You can obtain similar savings:

1. Eliminate machining and finishing operations.
2. Reduce scrap losses almost to zero
3. Eliminate cost of casting and forging intricate sections.
4. Reduce inventories because extrusions are quickly available.

Investigate this new production technique for your shape profiles—within present limits of a design which can be inscribed in a three-inch circle. You'll surely boost production, cut overall cost. For complete details write to the Jones & Laughlin Steel Corporation, Dept. 410, 3 Gateway Center, Pittsburgh 30, Pa.

Jones & Laughlin
STEEL ...a great name in steel

Circle 434 on page 19

ENGINEERING BULLETIN

ON MICRO-BEARINGS

Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH 1, NEW HAMPSHIRE

Subject: **FACTORS TO CONSIDER IN MINIATURE BEARING APPLICATION**

TYPES OF BEARING

The Retainer Bearing fitted with the one-piece crown retainer is well suited for the great majority of instrument applications. Even ball spacing produces good performance at low-moderate speeds, and it can also handle radial or thrust loads. Improved fabricating techniques result in crown retainers being specified for low-torque requirements.

Phenolic Retainers machined from phenolic plastic allow higher speeds and also provide some retention of lubricant. This retainer is used with angular contact bearings where one land is ground away from the inner or outer ring to permit bearing assembly. Such a design permits thrust *only* in the direction of the side having the full land.

CROWN

The Full Bearing has a full complement of balls. Filling notches are ground on one side of each ring to allow assembly. This type is steadily being replaced by retainer bearings which cost less to manufacture and assemble. It has an advantage for certain applications requiring maximum radial load capacity, but is unable to handle thrust loads because of possible interference between the balls and filling notches. Contact between the balls creates friction which makes the full bearing unsuitable for low torque or high speed applications.

PHENOLIC

MATERIALS

Stainless Steel's anti-corrosive properties have made it first choice for bearings used in precision instruments, and it has become one of the standard materials for this purpose. It can be ground and finished to a high degree of precision.

Chrome Steel should only be specified when bearings must operate at critical limits of capacity, a condition not often encountered in instruments. It has a somewhat higher load rating than stainless steel but is subject to rapid corrosion if not protected during handling and use.

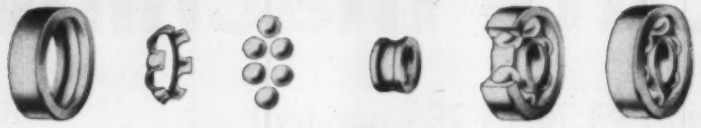
Beryllium Copper should be restricted to applications which definitely require non-magnetic properties in the bearings. All components of the bearing are fabricated from this material. If non-magnetic properties are not required, stainless steel is a better selection.

LOAD RATINGS

A miniature bearing is seldom operated at or near its rated load capacity. However, the designer must have sufficient information to assure intelligent selection. The load ratings presented in the New Hampshire Ball Bearings, Inc. catalog tables are based on standards established by the AFBMA after extensive studies and tests.

Dynamic load ratings apply to bearings that are rotating. Time-consuming calculations can be avoided by making use of the C factor shown in our catalog.

Static load ratings apply to bearings at rest. Since this exists in relatively few cases, static load rating is not usually given much emphasis. Formulae have been developed, however, and the need for this information is increasing, — primarily for units subjected to shock loading.



Retainer Bearing — Exploded and Assembled Views

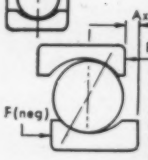
Retainer Bearing — Flanged and Shielded

RADIAL AND AXIAL PLAY

Radial play is the displacement of one ring with respect to the other along the *diameter* of the bearing.

It is important in the successful application of precision bearings and should be specified in orders. A range of .0002" to .0005" is satisfactory for most applications but tighter or looser clearances may be required. The minimum clearance should be .0001" and the total spread from min. to max. should be at least .0002".

Radial Play — Maximum distance one race may move diametrically with respect to the other without the application of measurable force when both races lie in the same plane.



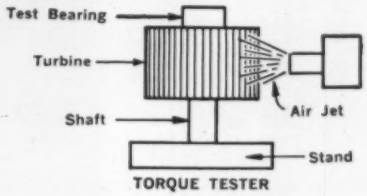
Axial Play — The maximum relative axial movement of inner race with respect to the outer, when both races are coaxially centered, without the application of measurable force.

Axial play is the displacement of one ring with respect to the other along the bearing axis. It is specified only when axial positioning of the shaft must be held within certain limits. Radial and axial play are mutually dependent factors and the former is the one usually specified.

TORQUE TESTS

Sensitive instruments require bearings with minimum inherent friction. Starting, or breakaway, torque is most often used to define limits. This is the force necessary to induce rotation from standstill under clearly established conditions of mounting and loading.

Torque tests can reveal much about the true quality and geometry of the bearing. Investigations being conducted constantly are producing valuable contributions to the refinement of instrument bearings.



TORQUE TESTER

MOUNTING PRACTICE

An improper fit to the shaft or housing can cause malfunctioning and failure of a precision bearing. The factors vary so with each application that bearing manufacturers are reluctant to make definite recommendations unless adequate information is furnished. The user cannot be sure that he has selected proper fits unless he has considered the variables involved in the manufacture of both instruments and bearings.

For selective assembly "coded bearings" can be supplied. This involves sorting bores and outside diameters in .0001" increments. It produces four possible groups within the quantity ordered but quantities in any *one* group cannot be assured. Coding should be specified only when definite advantages justify the additional cost.

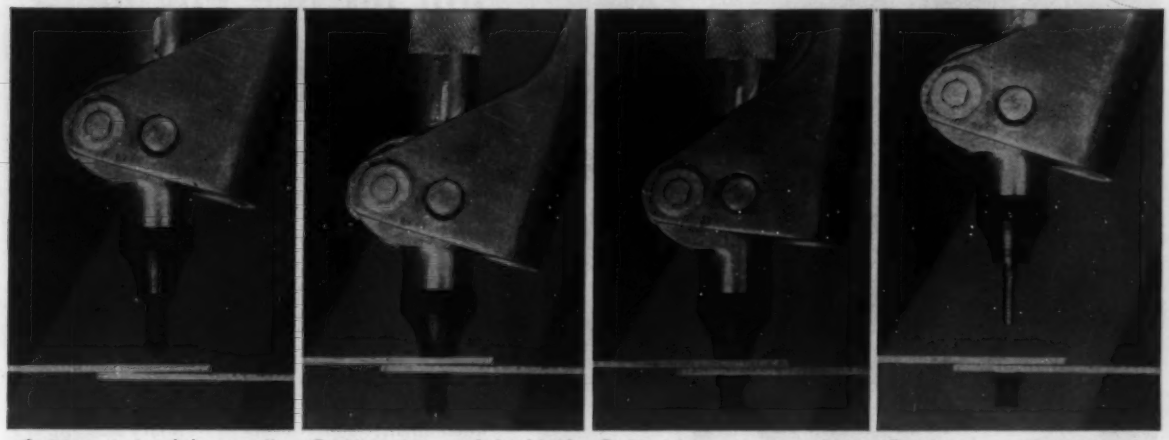
DESIGNERS HANDBOOK *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro - mechanical assemblies.

Free to engineers, draftsmen and purchasing agents.

Write New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

B.F. Goodrich Rivnut fastens thin metal and provides 6 threads . . . in 6 seconds!



1 Rivnut is threaded onto pull-up stud of heading tool.

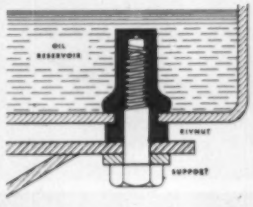
2 Rivnut is inserted—head held firmly against work.

3 Tool lever operates pull-up stud, forms bulge in Rivnut.

4 After upset, Rivnut threads are ready for screw attachment.

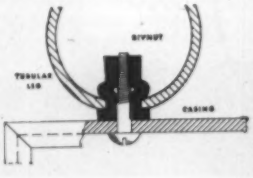
Easy way to cut assembly time and costs

SAVE TIME ON FASTENING JOBS LIKE THESE, WITH B. F. GOODRICH RIVNUTS.



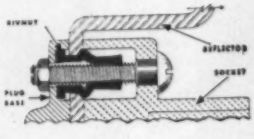
REPLACES BRAZED NUT PLATE

Rivnuts with closed ends are installed in one-tenth the time it took to braze nut plates on oil reservoir tanks. Leaking, warping and thread cleaning are eliminated, and spacer head assures proper positioning of tank on support bracket.



ELIMINATES NUTS AND BOLTS

One worker installs a Rivnut in the tubular leg of a portable barbecue in seconds—provides a firm, accurate nut plate for screw attachment. There are no boltheads to detract from the unit's clean lines. Time is saved, too, in faster knockdown for shipping.



DOES 2 FASTENING JOBS

Rivnuts provide 6-thread nut plate for attachment from either end—or both. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket. Plug base is attached on other side. Result: fewer operations, lower assembly cost.

Rivnuts, the only one-piece blind fasteners with threads, can be installed by one person from one side of the work—in seconds. Easy installation saves up to 50% of assembly time, reduces production costs. Rivnuts can also improve the appearance of a product, make it easier to use and service.

Rivnuts are made in a variety of sizes and head styles to solve almost any fastening problem. They make tight, dependable seals that resist vibration, stay put so you can assemble and disassemble the product as often as you like without stripping the threads. Welding, tapping and thread cleaning are eliminated. And you can install them after enameling without fear of chipping.

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs. They can do the same for you.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how Rivnuts fasten *to* and *with*. Explains construction, gives proved applications. Write to *B.F.Goodrich Rivnuts*, Dept. MD-47, Akron, Ohio.

B.F.Goodrich

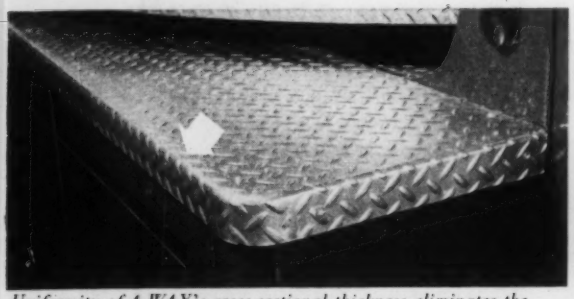
B.F.Goodrich Aviation Products

a division of The B.F.Goodrich Company, Akron, Ohio

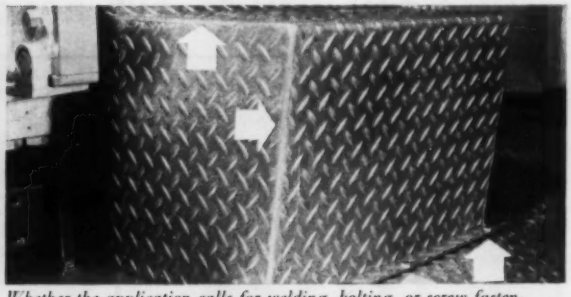
Circle 436 on page 19

tough fabricating job on fire engine proves 4-WAY'S® versatility

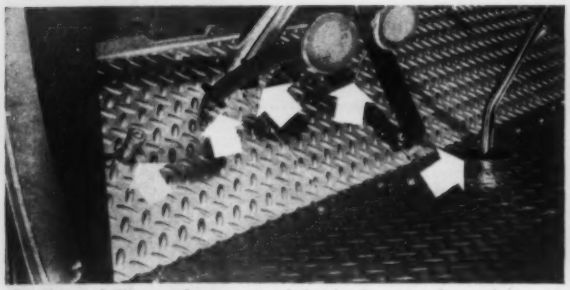
Fabrication to form even the varied and complex shapes used on firefighting equipment is no problem with 4-WAY Safety Plate. No special tooling is necessary. Ordinary cutting, drilling, forming and similar standard shop equipment is all that's needed. Good reason why this leading chassis and body manufacturer has specified Inland 4-WAY for more than 15 years! 4-WAY is used in an uncommonly wide variety of ordinary and extraordinary applications. For complete information and specifications, write Dick Prendergast, Room 1262 at the address below.



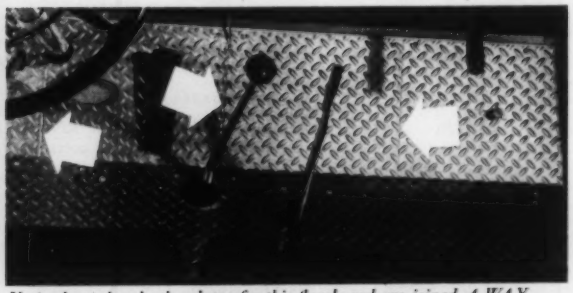
Uniformity of 4-WAY's cross-sectional thickness eliminates the possibility of deflection while bending, even at sharpest angles. Standard equipment can be used.



Whether the application calls for welding, bolting, or screw fastening, all are easily accomplished on 4-WAY with conventional methods.



Punching, drilling or flame cutting holes for fasteners, foot pedals, etc. is no problem with 4-WAY.



Notice how cleanly the plates for this floorboard are joined. 4-WAY can be sheared to extremely close tolerances eliminating all guesswork and make-overs.

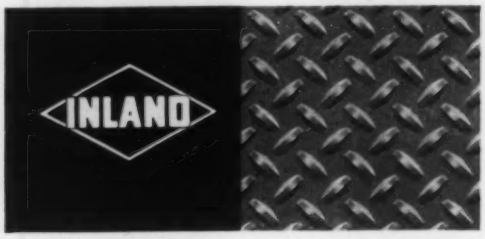
Inland 4-WAY® Safety Plate

Carried in stock by all leading steel distributors

INLAND STEEL COMPANY

38 South Dearborn Street • Chicago 3, Illinois

Sales Offices: Chicago • Milwaukee • St. Paul • Davenport
St. Louis • Kansas City • Indianapolis • Detroit • New York



OILITE parts in power saw resist wear better than steel and cost less

Another cost-saving application of **Amplex Powder Metallurgy**

With a modern power saw—easy does it. It's easier on the inside, too, because this manufacturer has equipped vital components with extra tough, greater wear resistant OILITE precision parts. The manufacturer's report indicates that OILITE powder metal sprockets and gears offer *greater wear resistance than alloy steels.*

Furthermore, in using OILITE precision parts the manufacturer of the power saw realizes *substantial cost savings over parts fabricated by any other process.*

What this manufacturer is accomplishing with OILITE precision parts, you can too. Or, perhaps, in your case OILITE self-lubricating bearings and bearing materials can help you lick the problem of providing lubrication in hard-to-get-at places. In permanent metal filters, too, OILITE provides a wide choice of shapes, sizes and porosities to meet product requirements.

Amplex—volume producer of Chrysler-engineered powder metal components—can meet your production schedules with on-time deliveries in any quantity.

Helping solve the problem of others is a daily occurrence at Amplex. This Chrysler-Amplex engineering service is available to you too.

Representatives and dealers located in principal cities in United States and Canada.

A CHRYSLER OILITE PRODUCT

Only Chrysler Makes **OILITE**

AMPLEX DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

New 24 page OILITE bronze bearing stock list. Contains over 1000 sleeve, flange and thrust bearings—cored, bar and plate stock —engineering data. Write for booklet S-56. Address Dept. 4C.

Bearings • Finished Machine Parts • Permanent Metal Filters • Friction Units

Circle 438 on page 19

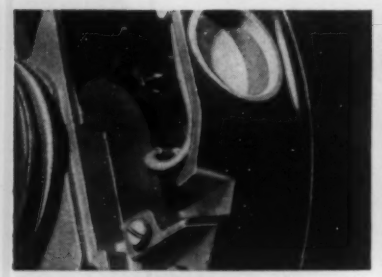
It's easy to handle the new Westinghouse 48-frame motor

These five big mechanical advantages prove it!

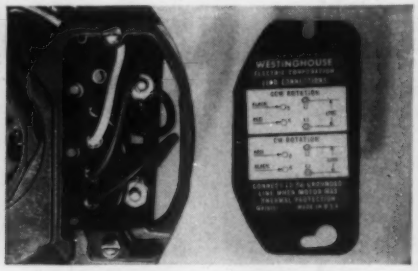
Up to 35 pounds of pull will not disconnect the line cord on this new Westinghouse 48-frame motor. A built-in strain relief, one of this motor's many mechanical features, was designed with you in mind.

The mechanical advantages you get with the new Westinghouse 48-frame simplify your product design problems. They help speed up your assembly—make it easier and less costly. And they assure you of the permanent dependability you need and require to help make *your* product better—more salable.

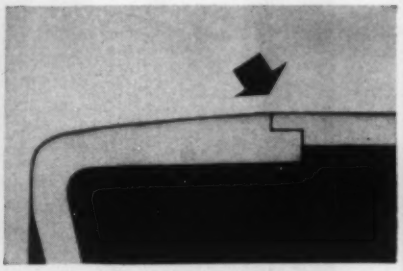
For more information on the mechanical and other advantages of the new, lighter, more compact Westinghouse 48-frame motor, contact your nearby Westinghouse sales engineer. Or, write for descriptive bulletin DB-2801 to Westinghouse Electric Corporation, P. O. Box 566, Lima, Ohio. J-03030-X



POSITIVE CONNECTIONS are assured with the Westinghouse built-in strain relief for line cords. Easy-to-get-at knockout permits quick threading of conduit into spacious terminal box.



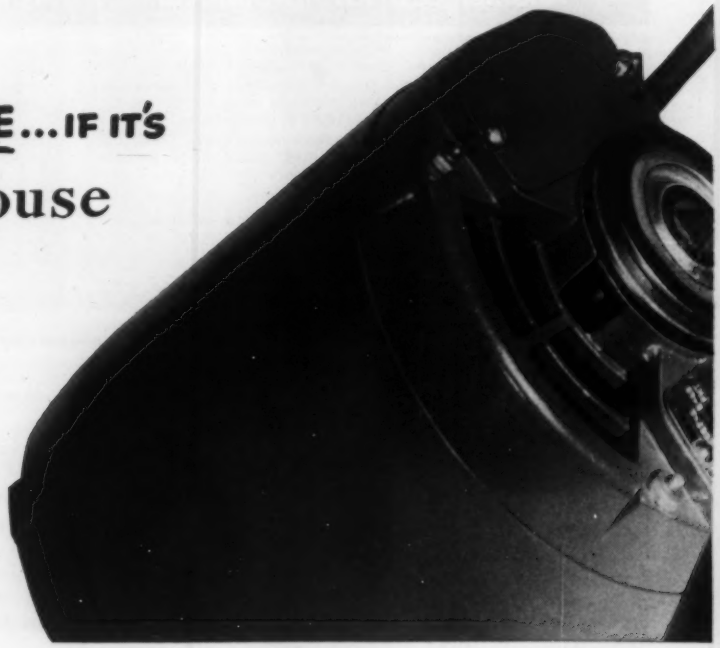
SIMPLE CHANGE of voltage and rotation is possible with easily accessible plugs on a modern terminal board. Motor's versatility materially reduces stocking requirements.



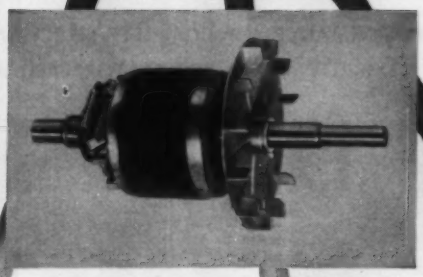
HEAVY FRAME with machined fit for end brackets assures positive alignment. Absence of "Swiss-cheese" vents in solid frame protects windings against liquids or dirt.

YOU CAN BE SURE... IF IT'S

Westinghouse



WELDED FOOT provides an absolutely rigid mounting—assures accurate control of shaft height. Rigid or resilient mounted, these new motors can be operated in any position.



CONTROLLED CONCENTRICITY through use of centerless ground shaft and dynamically balanced, aluminum die-cast, skewed rotor assures even torque and extra-quiet operation.

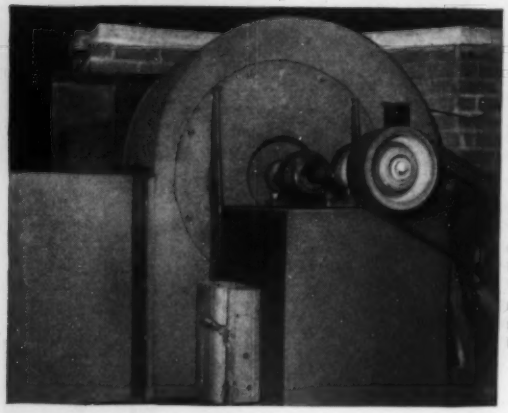
We would like to say that we are very well pleased with the "Buffalo" Fans we are using on our tunnel kiln installations. The "NV" Propeller Fan which Buffalo Forge designed for us for our drier operation is undoubtedly the best fan of this type we have used.

— from a leading manufacturer who builds "Buffalo" Fans into his products (name on request)

...and here's why

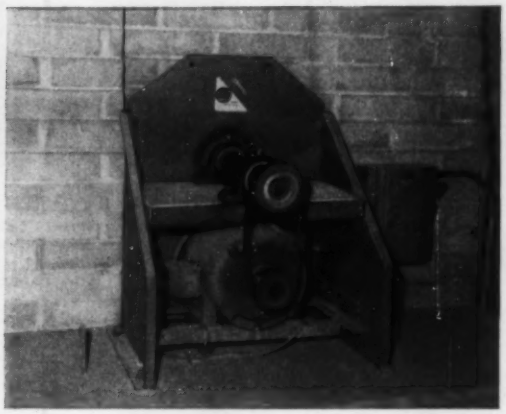
"BUFFALO" FANS WILL SUIT YOU, TOO

- HIGH EFFICIENCY
- QUIET OPERATION
- STABLE PERFORMANCE
- DESIGN FLEXIBILITY
- COMPLETE SELECTION
- "Q" FACTOR* RELIABILITY
- "SPECIAL" FANS ENGINEERED-TO-ORDER



At left — "Buffalo" Type "BL" Fan moving 14,000 cfm waste heated air from Tunnel Car Kiln to dryer.

At right — One of 3 "Buffalo" Dryer Recirculating Fans on Car Kiln. "Buffalo" "NV" Propeller Wheel mounted on end of shaft projected thru kiln wall.



INQUIRIES CONCERNING YOUR AIR HANDLING PROBLEM ARE INVITED.

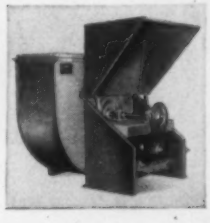
**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY

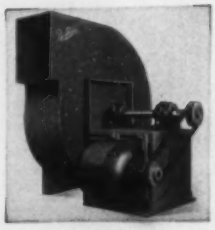
BUFFALO, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

"Buffalo" Volume Fans for blowing, exhausting jobs up to 10" s. p., have moisture-proof cast iron housings, dust-proof ball bearings.



"Buffalo" Belted Vent Sets are light-weight "packages" for small-system ventilation. Highly efficient and quiet. Write for Bulletins.



"Buffalo" All-Welded Industrial Exhausters handle any materials suitable for a pneumatic system. Heavy steel plate wheels and housings.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

Circle 440 on page 19

solve many difficult control problems...use

OHMITE®

RHEOSTATS

with special features

Ohmite offers not only a line of *standard* rheostats but also rheostats with a wide variety of *special features*. Illustrated are only a few. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. You will find the special rheostat feature you need in the dependable Ohmite line.

BUSHINGS FOR SPECIAL THICKNESS

Extra-long bushings and shafts for panels up to 2" in thickness. Seven bushing lengths.

SCREW DRIVER SLOT SHAFT

Shaft ends slotted for operation with a screw driver where few adjustments are needed.

VENTILATED CAGES

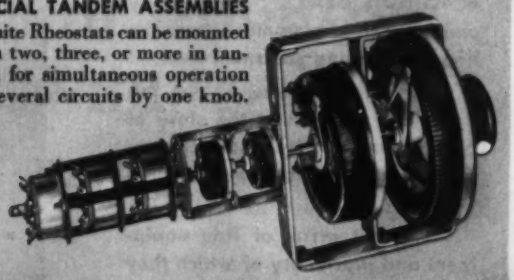
Prevents mechanical injury to rheostat or human contact with electrically "live" parts.

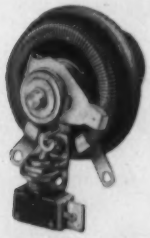
SENSITIVE SWITCH

Opens or closes circuit with minimum movement of control knob shaft. Extremely dependable long life switches.

SPECIAL TANDEM ASSEMBLIES

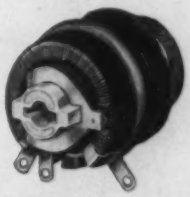
Ohmite Rheostats can be mounted with two, three, or more in tandem for simultaneous operation of several circuits by one knob.





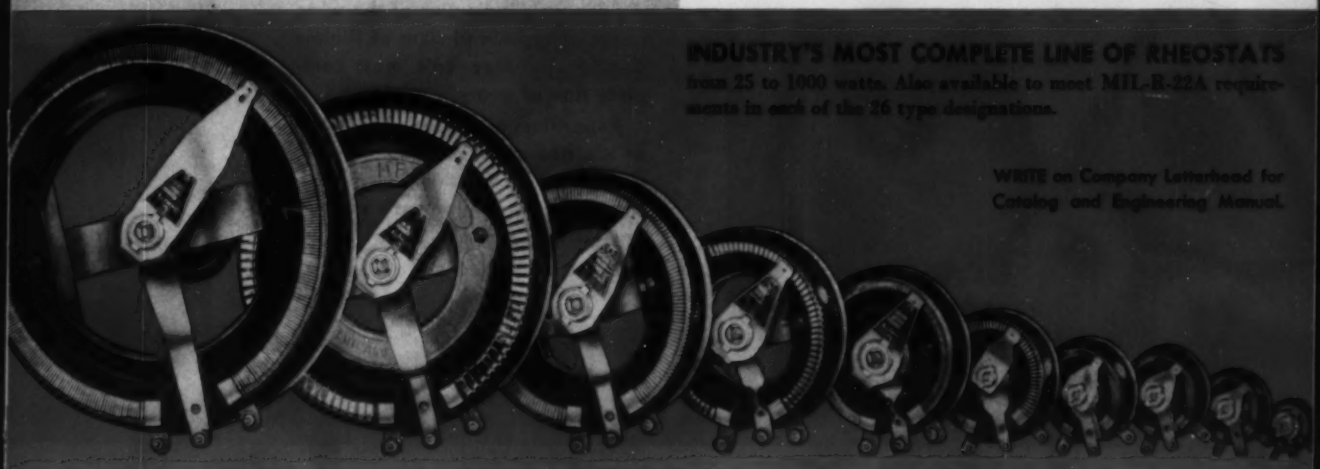
TOGGLE SWITCH

Is operated with a positive snap by the rheostat arm at either end position. Used for heavy-duty applications.



WITH OFF POSITION FEATURES

Opens circuit at high or low resistance position with *snap-action* (illus.); opens circuit at high resistance position with *dead lug* off position; or has *dead section* off position.



INDUSTRY'S MOST COMPLETE LINE OF RHEOSTATS

from 25 to 1000 watts. Also available to meet MIL-R-22A requirements in each of the 26 type designations.

WRITE on Company Letterhead for Catalog and Engineering Manual.

BE RIGHT WITH

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS

OHMITE®

OHMITE MANUFACTURING COMPANY, 3618 Howard Street, Skokie, Illinois

Circle 441 on page 19

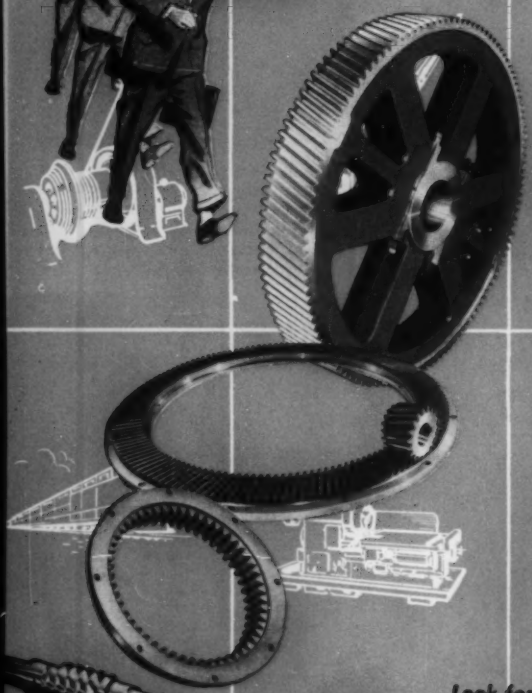
...22,461 SALESMEN on the job every day for ILLINOIS GEAR

The more than 22,461 customers of ILLINOIS GEAR . . . *and every one a satisfied customer*... are the hardest working salesmen ever.

Gears they use are on the job every day . . . telling the story of outstanding quality and performance that characterizes Illinois Gears.

The great array of fine equipment and machinery of which they are a part is indicative of the wide range of types and sizes of Illinois Gears . . . America's *most complete line of gears.*

Regardless of the service, whether it's gears for rotating massive shovels, or gears that control delicate precision equipment — depend on ILLINOIS GEARS.



Look for this mark ILL® *the symbol on finer gears*

ILLINOIS GEARS
* Reg. U.S. Pat. Off.

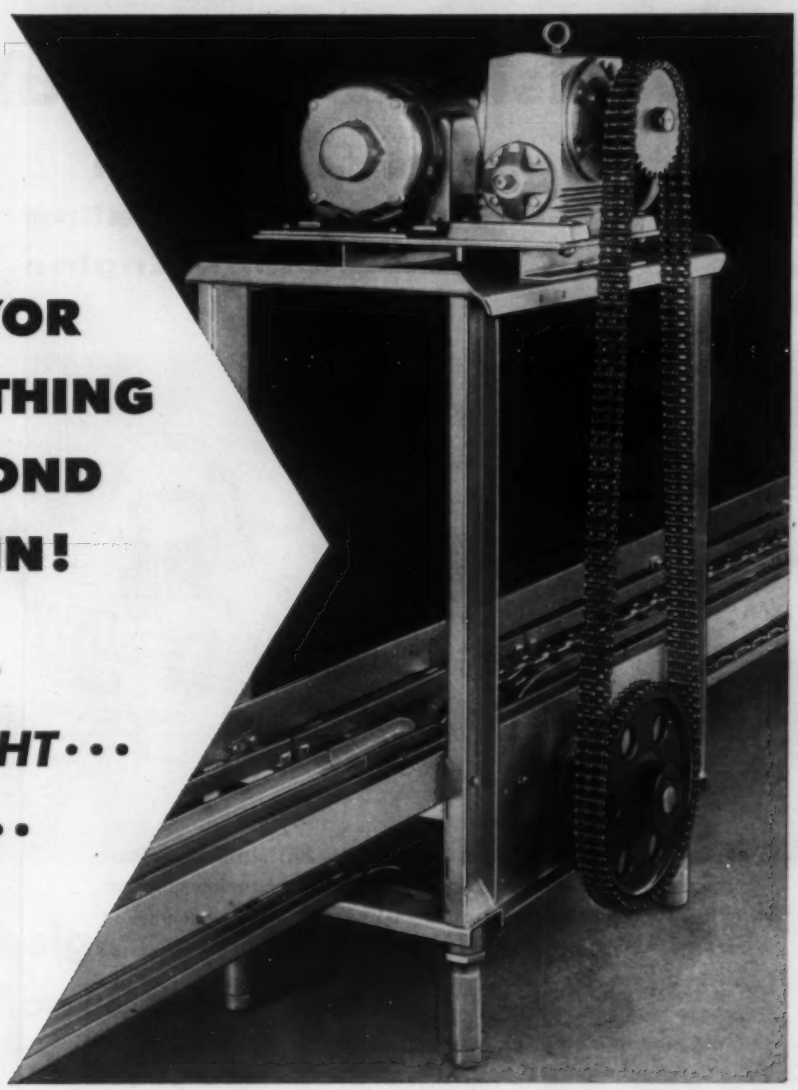
Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

Circle 442 on page 19

FOR CONVEYOR DRIVES—NOTHING BEATS DIAMOND ROLLER CHAIN!



POSITIVE • • •

LIGHT WEIGHT • • •

LONG LIFE • • •

FLEXIBLE • • •

● On this model of a Cherry-Burrell Case Conveyor, the power drive is located some distance *above* the conveyor shaft. On others the drives may be shorter or located below the shaft. In any case the Diamond Roller Chain assures non-slipping power transfer in the most practical and economical manner.

Gears would require more bulk and weight, with costly shafts and bearings.

Belts for this kind of application cannot provide the accuracy of conveyor movement and timing.

Diamond Roller Chains are highly flexible in application. Their *light weight* in relation to power transferred helps improve machinery design. The *efficiency* of Diamond Roller Chains cannot be matched by any other method of power transmission.

Diamond Application Engineers have sixty-seven years of experience to draw from in making recommendations. This experience is available to help solve your drive problems. No obligation of course.

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana

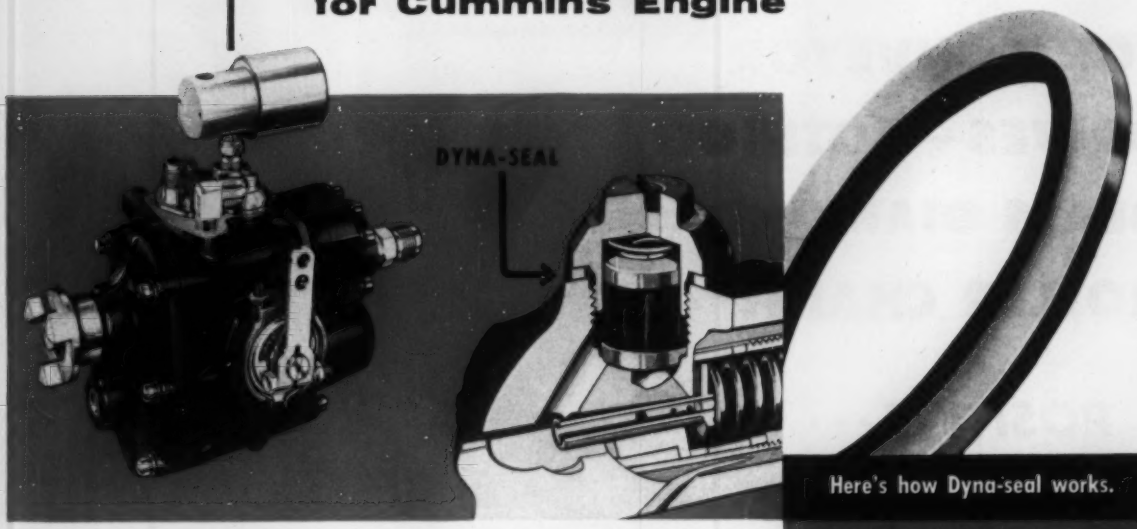
Offices and Distributors in All Principal Cities

DIAMOND **ROLLER CHAINS**

Circle 443 on page 19

Precision Dyna-seals...

provided leak proof vibration proof sealing for Cummins Engine

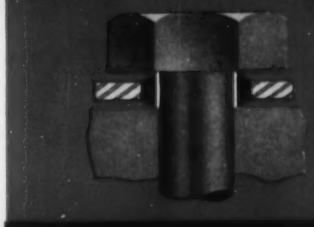


In the Cummins Engine fuel system, a filter screen in the pressure regulator is a vital element. This filter must be readily accessible for occasional cleaning, yet perfect operation requires vibration proof and leak proof sealing of the filter chamber to avoid loss of power. Dyna-seal filled those sealing requirements.

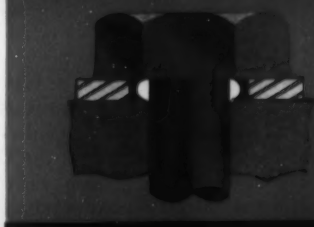
Dyna-seals bring to an end the face-to-face sealing problems of many other manufacturers in automotive, mining, industrial and marine fields. This practical one-piece unit, consisting of a flared rubber sealing ring, heat and pressure bonded to a steel washer provides a positive seal against pressure of up to 10,000 P.S.I. It eliminates grooves and special machining – reduces tooling – cuts assembly costs – may be re-used.

Dyna-seals give exacting performance under bolt and rivet heads, cap nuts, flanges or special fittings. Let a Precision engineer demonstrate the many Dyna-seal cost and labor-saving advantages to you. Write today!

Here's how Dyna-seal works.



Dyna-seal before bolt head is drawn down. Note flare of sealing member.



Bolt head drawn down. Lock washer action. Bolting torque reduced.

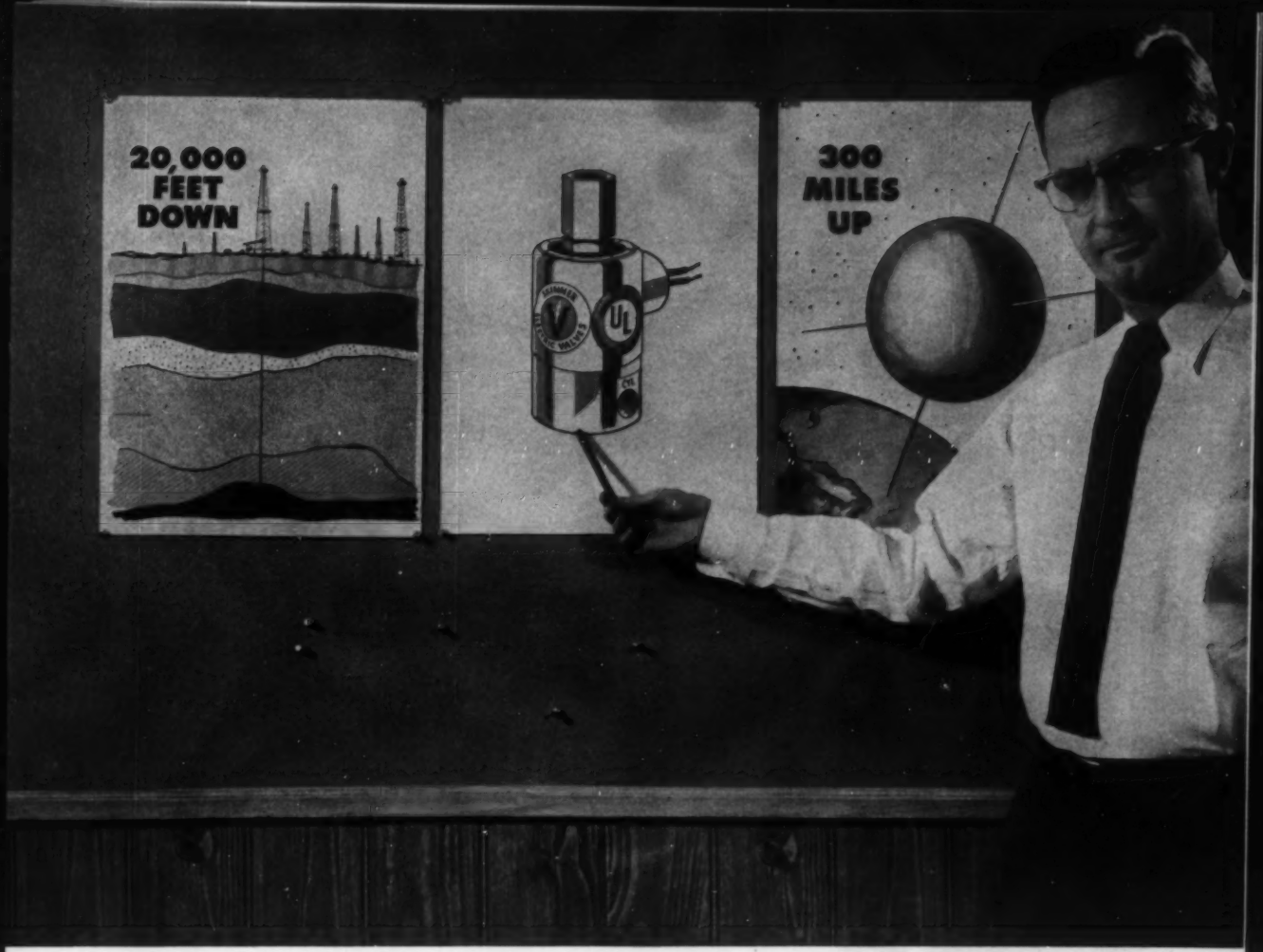
Write for your free copies of Precision catalogs on "O" Rings and Dyna-seals

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio

Canadian Plant at: Ste. Thérèse de Blainville, Québec

Circle 444 on page 19



The versatile design of Skinner Solenoid Valves makes their applications almost unlimited

Skinner Solenoid Valves have such great versatility that no one, not even their makers, knows the full extent of their applications. The range of their extremes demonstrates this vividly. One Skinner valve is being used in an instrument in Texas oil wells that tells the nature of earth strata 20,000 feet below the surface. Another one will be used to help launch the satellite that soon will be circling the globe.

If you have a problem that a solenoid valve might conceivably solve, we urge you to talk to a Skinner representative. Fill him in on the nature of your application. He'll be glad to work with you in selecting a valve that matches your requirements as to port sizes and locations, voltages, pressures, temperature conditions, flow adjustments and mountings.

For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 424.

Skinner Solenoid Valves are distributed nationally

Circle 445 on page 19

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

THE CREST OF QUALITY

One of these Monarch casting methods offers you

MORE CASTING VALUE PER DOLLAR

When you check Monarch's non-competitive casting analysis, every phase of production, including machining, finishing and assembly, is properly evaluated. Monarch mass-produces castings by all three methods, with more than 20 years experience. Monarch operates the largest finishing department of any commercial foundry. This broad manufacturing experience assures you "non-competitive", unbiased answers to the manufacturing problems of your end-product—and more casting value per dollar. Consult Monarch today for improving end-product performance at lower factual end-cost.

- *Aluminum permanent mold fry-pan, cast in heating element, colorful Spectraglaze® porcelain enamel finish.*
- *Certified zinc electronic housing, as cast, commercial trimmed.*
- *Aluminum die cast portable tool, mar-resistant Velvaglaze® finish.*

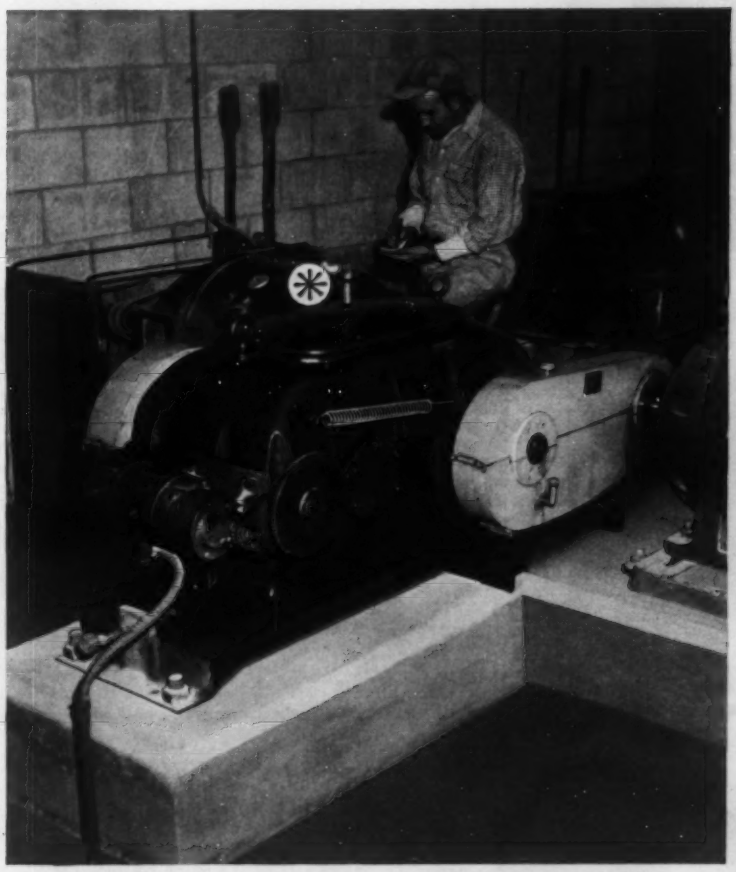
SINCE 1913
MONARCH
ALUMINUM
PIONEERS IN CASTING PROGRESS

® Velvaglaze and Spectraglaze are Trade Marks of

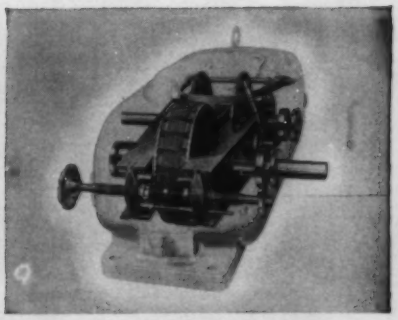
MONARCH ALUMINUM MFG. COMPANY—9205 DETROIT AVENUE—CLEVELAND 2, OHIO—OLympic 1-1700

MANUFACTURERS OF: *Aluminum Permanent Mold Castings • Zinc Die Castings • Aluminum Die Castings • Exclusive Velvaglaze Finishing • and Spectraglaze, colorful Porcelain Enamel on Aluminum Permanent Mold Castings.*

Circle 446 on page 19



LINK-BELT P.I.V. variable speed drive with remote control, synchronizes several drive units on a continuous gypsum board forming machine. P.I.V. is available in 8 sizes and 16 types for horizontal or vertical mounting, with or without integral motor.



ALL-METAL CONSTRUCTION, shown in phantom, means long operating life with little wear and maintenance.

AUTOMATIC CONTROLS are available for self-regulation of P.I.V. This jute slasher is controlled electronically.

COMPLETE DATA. Book 2274 suggests uses for P.I.V. in timing, synchronization, many other jobs. Book 2349 covers controls.

Variable speeds, unvarying accuracy

provided by stepless, positive Link-Belt P.I.V. drives

REGULATING machine and conveyor speeds . . . synchronizing and timing operations . . . metering material flow or controlling rotary motion —for countless jobs requiring infinitely variable control of rpm, all industry uses Link-Belt P.I.V.

Whereas ordinary variable speed drives depend on friction to transmit power, P.I.V. operates with an ingenious, slipless chain. It engages in radial grooves of two sets of wheels on input and output shafts. As the operator turns the control screw, one set of wheels closes . . . the other spreads. The self-tooth-forming chain automatically adjusts itself to the wheel diameters to provide desired ratio.

This grip assures positive selection of any speed from maximum to minimum settings—with any size loads and without interrupting machine operation. P.I.V. is unexcelled for accuracy, and its principle has been proved in many years of efficient service. Performance is quiet, trouble-free, unaffected by atmospheric conditions. To learn how it can extend the useful range of your machines, call your nearest Link-Belt office.

LINK-BELT P.I.V. VARIABLE SPEED DRIVE

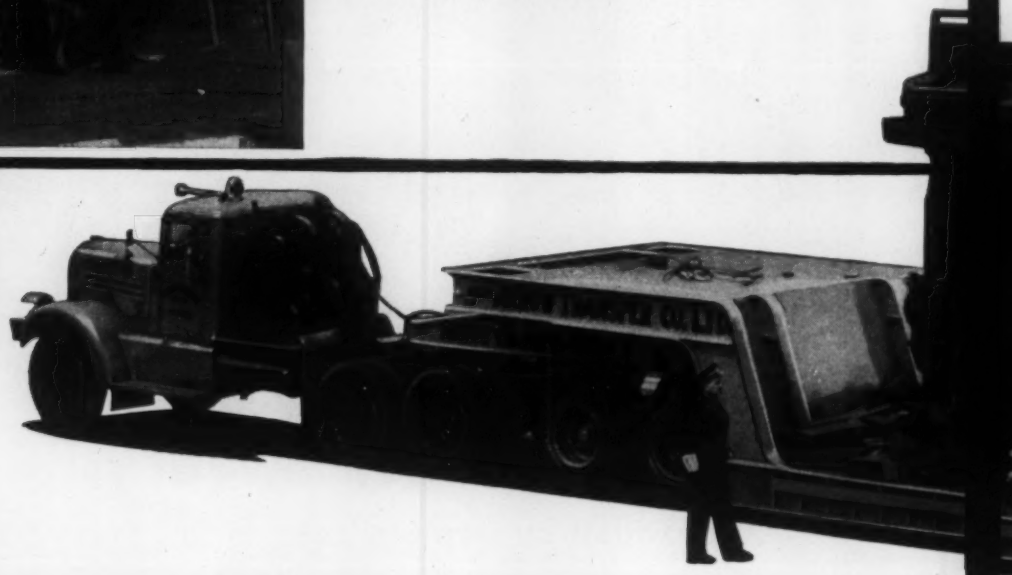
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,310

INCREASES CORROSION RESISTANCE. The huge rotor illustrated here is the main structural component of a Ljungstrom Horizontal Air Preheater. Three of these units, designed to serve a 1,900,000 pounds-per-hour-capacity boiler, are among the largest ever manufactured by The Air Preheater Corporation, New York. Each complete preheater weighs 270 tons. The rotor itself—25′2″ in diameter and 10′10½″ deep—when fully loaded with the heating element, weighs about 390,000 lbs.

Because sulfur in the gases combines with moisture—sulfuric acid is formed when the temperature drops below the dew point at the "cold" end of the rotor—corrosive action can be highly severe in this area. Corrosion means maintenance.

Aiming at a reduction in maintenance, the manufacturer cooperated with the U. S. Bureau of Mines in exhaustive tests to determine the corrosion resistance of various materials under sulfuric acid attack in air preheaters. These tests, made over a 5½-year period, showed that the corrosion rate of low-alloy USS COR-TEN Steel was *lower* than all but one of the *high* alloy steels tested, was less than one-half that of carbon steel and less than one-fourth that of cast iron.

As a consequence, USS COR-TEN Steel is specified for the cold end heating elements and containing baskets on all conventional boiler applications. Where unusually severe corrosion is anticipated, USS COR-TEN Steel is also specified in all or part of the rotor including diaphragm plates, bar stock, rim angle and filler plates.



INCREASES DURABILITY, REDUCES COST. Tote boxes have to take quite a beating. Used for handling, storing and shipping automotive and other parts, they must be able to withstand plenty of rough treatment.

That's why the "Hamlintainer" shown here—a *collapsible* tote box that sets up and folds flat in less than 20 seconds—is now built entirely of USS COR-TEN Steel. COR-TEN Steel's greater strength, 50% higher than carbon steel, makes it possible to build the "Hamlintainer" up to 100 lbs. lighter than carbon steel units, yet so strong and rigid that it will withstand long and rugged service and is not susceptible to bending and distortion. The fact that the COR-TEN Steel ends and sides have the stamina needed to permanently maintain their shape is of utmost importance. It means that throughout its long life the box will always be easy to set up, fold and stack flat.

As compared to the metal construction used in an earlier design, USS COR-TEN Steel makes the "Hamlintainer" not only stronger, more rigid and more durable but also less costly to produce, according to the manufacturer, Hamlin Metal Products Co., Akron, Ohio.

High-strength USS COR-TEN Steel pays off in equipment like this

What does your product need to make it better? Greater durability? Bigger capacity? Cheaper maintenance? Lower operating cost?

Do you want to make it stronger, lighter in weight, more corrosion resistant, better able to withstand abrasion, impact and fatigue?

You can obtain any or all of these important money-saving benefits—at little or no increase in cost—by the proper use of high-strength low-alloy USS COR-TEN Steel.

USS COR-TEN Steel is distinguished by its superior resistance to atmospheric corrosion—4 to 6 times that of carbon steel, 2 to 3 times that of copper steel.

In thickness of ½" and under, COR-TEN Steel has a minimum yield point of 50,000 psi and a minimum tensile strength of 70,000 psi. In resistance to abrasion, shock and impact, it is superior to structural carbon steel. Its fatigue resistance is 60% greater.

Thus, when used to directly replace carbon steel, USS COR-TEN Steel will materially increase the strength and durability of vital parts *without* increasing their weight. Or it can be used in thinner sections (1) to reduce weight without sacrificing strength or (2) to increase the capacity of equipment without increasing gross weight or the power required to move it.

You will find our 174-page "Design Manual for High Strength Steels" extremely useful in applying USS COR-TEN or our other High Strength Steels, USS MAN-TEN and USS TRI-TEN "E" to your product. For free copy, simply write on your company letterhead to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

INCREASES STRENGTH, SAVES WEIGHT. Shown here hauling a 117-ton transformer, this 150-ton-capacity trailer—built by Columbia Trailer Company, Vancouver, B. C., for the Arrow Transfer Company of that city—is the largest trailer ever built in Canada.

This 80-ft.-long trailer is constructed almost entirely of USS COR-TEN Steel. It is about 25% lighter than if it had been built of structural carbon steel. Specifically designed for handling transformers of giant size, it has a depressed center deck which makes loading and unloading easier and keeps center of gravity low to prevent danger of upset.

Says the manufacturer: "We have found that when a trailer is made from structural carbon steel there is a greater possibility that it can be permanently damaged from overloading than in the case of a similar unit made from high strength steels. That's why, in designing trailers of this type, we always use USS COR-TEN Steel. This construction gives us the high strength needed, plus excellent corrosion resistance and freedom from excess weight—all very important in equipment like this."

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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USS HIGH STRENGTH STEELS

USS MAN-TEN • USS COR-TEN • USS TRI-TEN

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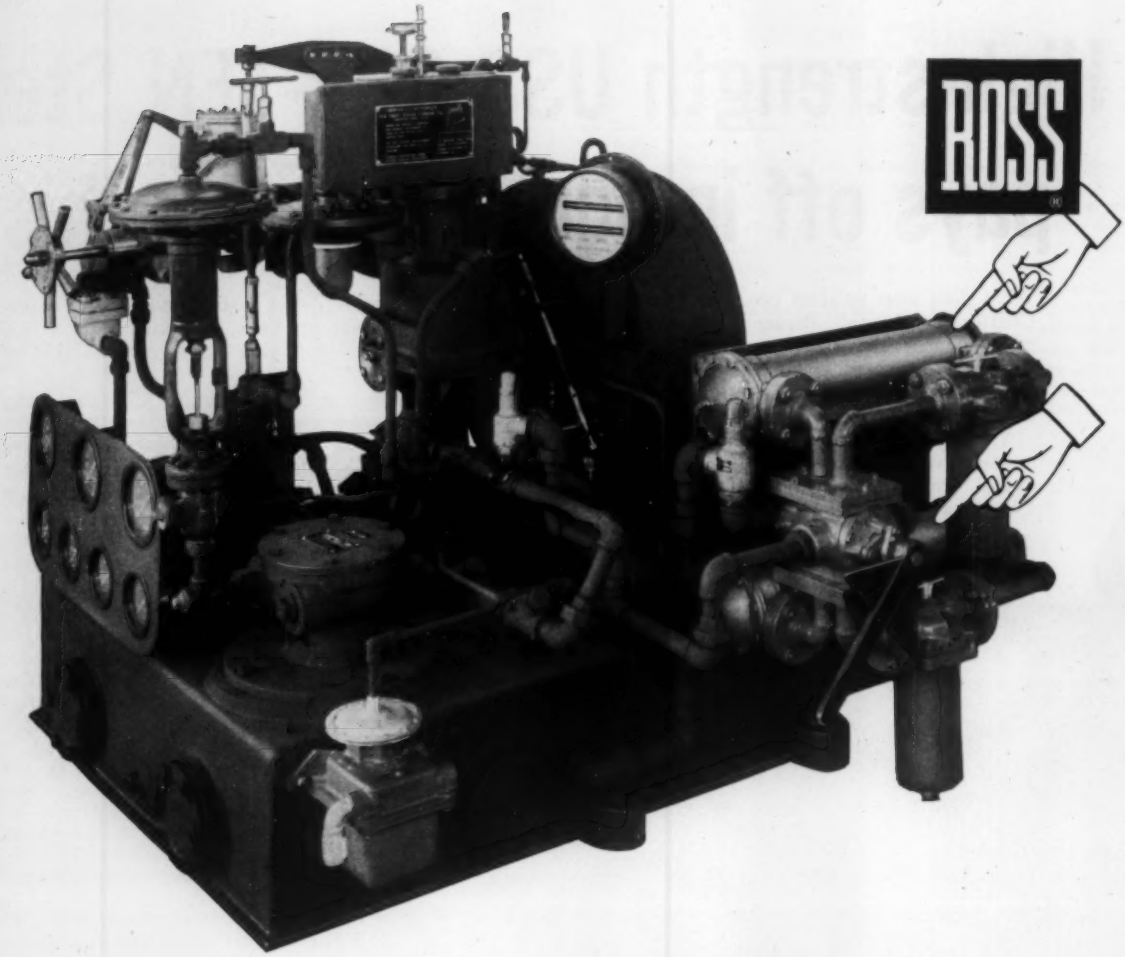
UNITED STATES STEEL



dependable ROSS EXCHANGERS assure temperature-safe lubrication of this Terry Turbine

Rated 450 hp at 7450 rpm, this single-stage Terry Steam Turbine drives a centrifugal compressor in a refinery.

To maintain continuous, trouble-free performance, two Ross Type BCF Exchangers have been installed as original components in its lubrication system. Excessive heat is dissipated, and correct lube oil viscosity maintained. The main journal, thrust bearings and governor receive their full share of properly cooled oil at all times.

Because of their high thermal efficiency, Ross Exchangers safeguard numerous types and makes of machinery serving the oil and gas industry: compressors, turbines, engines, blowers, reduction gears, centrifugal pumps, torque converters and fluid drives. Rugged and compact, they're easy to install, easy to maintain.

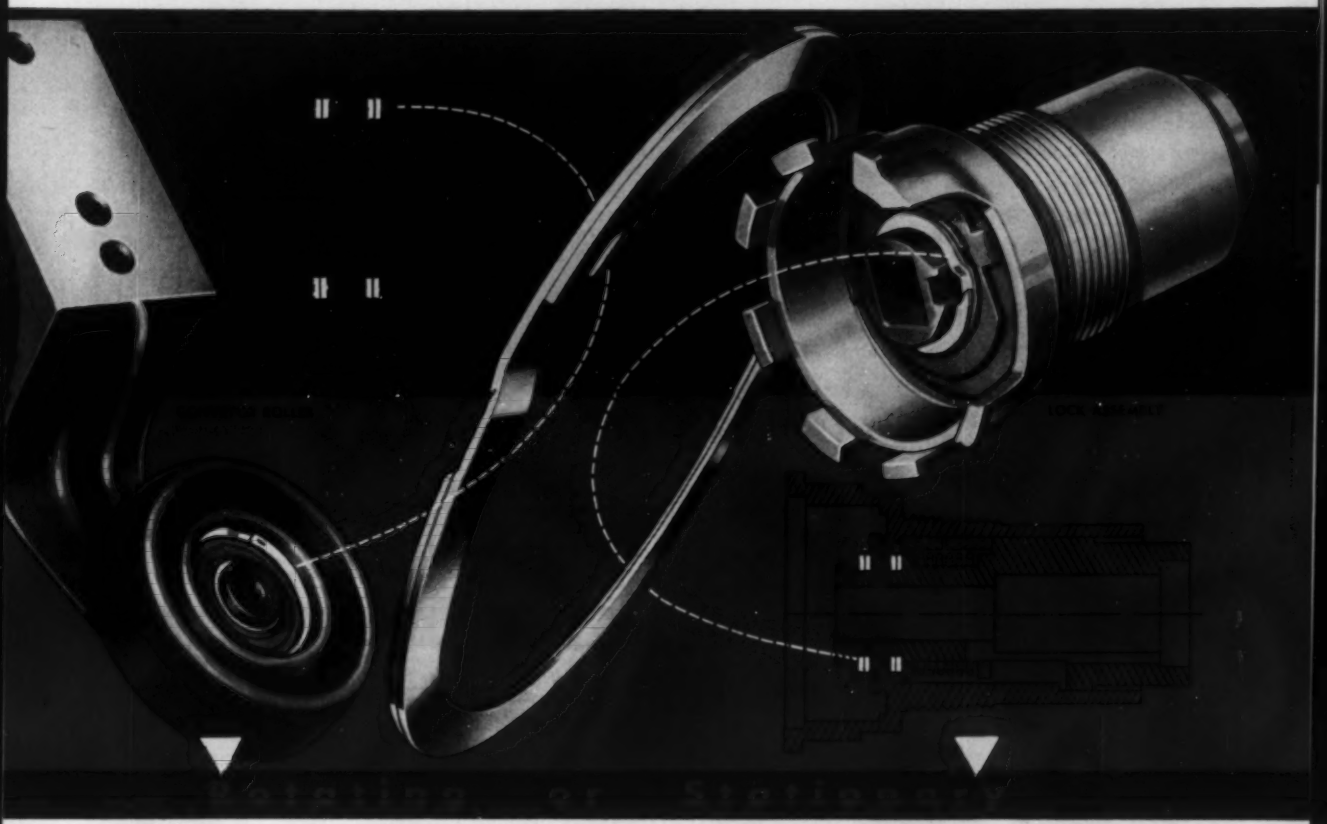
Completely pre-engineered and fully standardized, Ross Exchangers are available in a wide range of sizes to meet your heat transfer requirements. Learn what these non-ferrous units can do for you by requesting Bulletin 1.1K5. Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y. In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS HEAT EXCHANGER

Division of AMERICAN-Standard

Circle 449 on page 19

there are hundreds of ways in which Industry uses **SPIROLOX** to solve retaining problems



assemblies retained with SpiroLox look neater, last longer, use fewer parts, are easier to take apart and put together

Wherever parts rotate, wherever parts are to be secured on shafts or in housings, wherever moving parts must *hold* together —Spirolox Retaining Rings do the job better! Even on rotating assemblies, as shown in the conveyor roller application at left above, Spirolox attains neat, compact, simplified design. The stationary application of a lock assembly (right above) illustrates how Spirolox can be applied in those hard-to-reach places where the retaining ring must operate in a very confined space.

Exclusive Spirolox Design makes possible a variety of applications that is almost limitless. Secret of this design is the patented Spirolox *two-turn construction*, which ELIMINATES THE GAP and makes possible a UNIQUE LOCKING CHARACTERISTIC. A step or offset, formed in the ring so that the two turns are parallel, *bridges the gap* found in conventional retaining rings. Result: better conformability, even in the most restricted places. The effective locking property of Spirolox is created by a "friction lock", formed under thrust between the two turns. Result: greater holding power to make the ring STAY PUT in its groove.

The success of Spirolox construction proves itself not only in superior operation. It also makes possible easier installation, less-complicated machining, simplified servicing and quicker dismantling of assemblies retained the Spirolox way. These compact spring-steel rings spiral into their grooves easily, saving many man-hours in manual installation. Spirolox Rings adapt easily to fixtures for automatic production line installation. They eliminate costly machining and special tools. Spirolox Rings facilitate maintenance and servicing in the field because they come out at the flip of a screwdriver, ready for re-use. Thus, factory-adjusted or assembled units REMAIN UNCHANGED, even after repeated dismantling operations during servicing or repairs.

HANDY, ILLUSTRATED SPIROLOX CATALOG is yours without cost or obligation. It may be your key to simpler, lighter, more compact machinery or parts. If you wish, send us a print of your product and our engineers will point out Spirolox application possibilities. Thompson Products, Inc., Piston Ring Division (Ramsey Corporation) Dept. B, St. Louis 8, Mo.

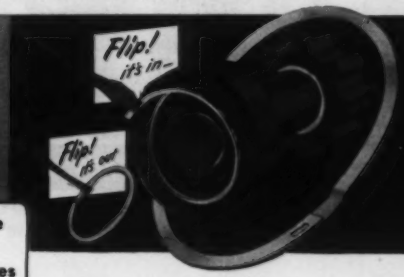
U.S. Pat. No. 2,450,425 and Foreign Pats. Other Pats. Pend.

B-6012RT

the better way

SpiroLox RETAINING RINGS

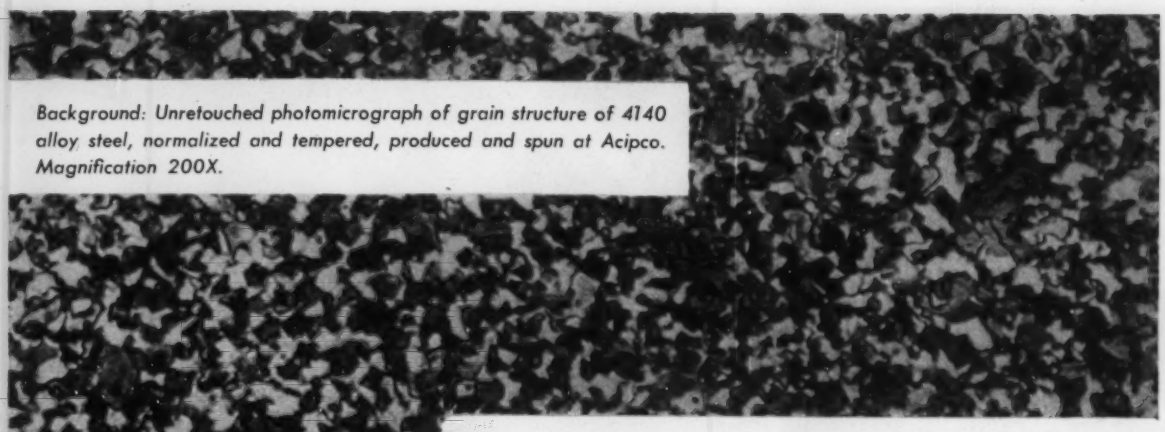
to hold moving parts TOGETHER!



Write for Samples

gapless • concentric • requires no special tools • easy-in, easy-out • re-usable • stays put

Circle 450 on page 19



Background: Unretouched photomicrograph of grain structure of 4140 alloy steel, normalized and tempered, produced and spun at Acipco. Magnification 200X.

A Better Pattern For Your Designs...

ACIPCO

Centrifugally Spun STEEL TUBES

This photomicrograph of the grain structure of the Acipco steel tube shows why parts made from these quality tubes are both easier to make and more economical to use.

Because it is centrifugally spun, the Acipco steel tube grain structure is more even, more dense, and more free from inclusions. This non-directional granular pattern means easier machining, greater strength, and greater durability in any design.

Non-directional grain structure is only one of the advantages you get when you specify and use Acipco Steel Tubes. If you manufacture or design products requiring tubular steel, write or call for full information about Acipco steel tube applications in your field.

SIZE RANGE: Lengths up to 16′ — longer lengths by welding tubes together. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

FURNISHED: As cast, rough machined, or finish machined, including honing.

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17 Grand St.
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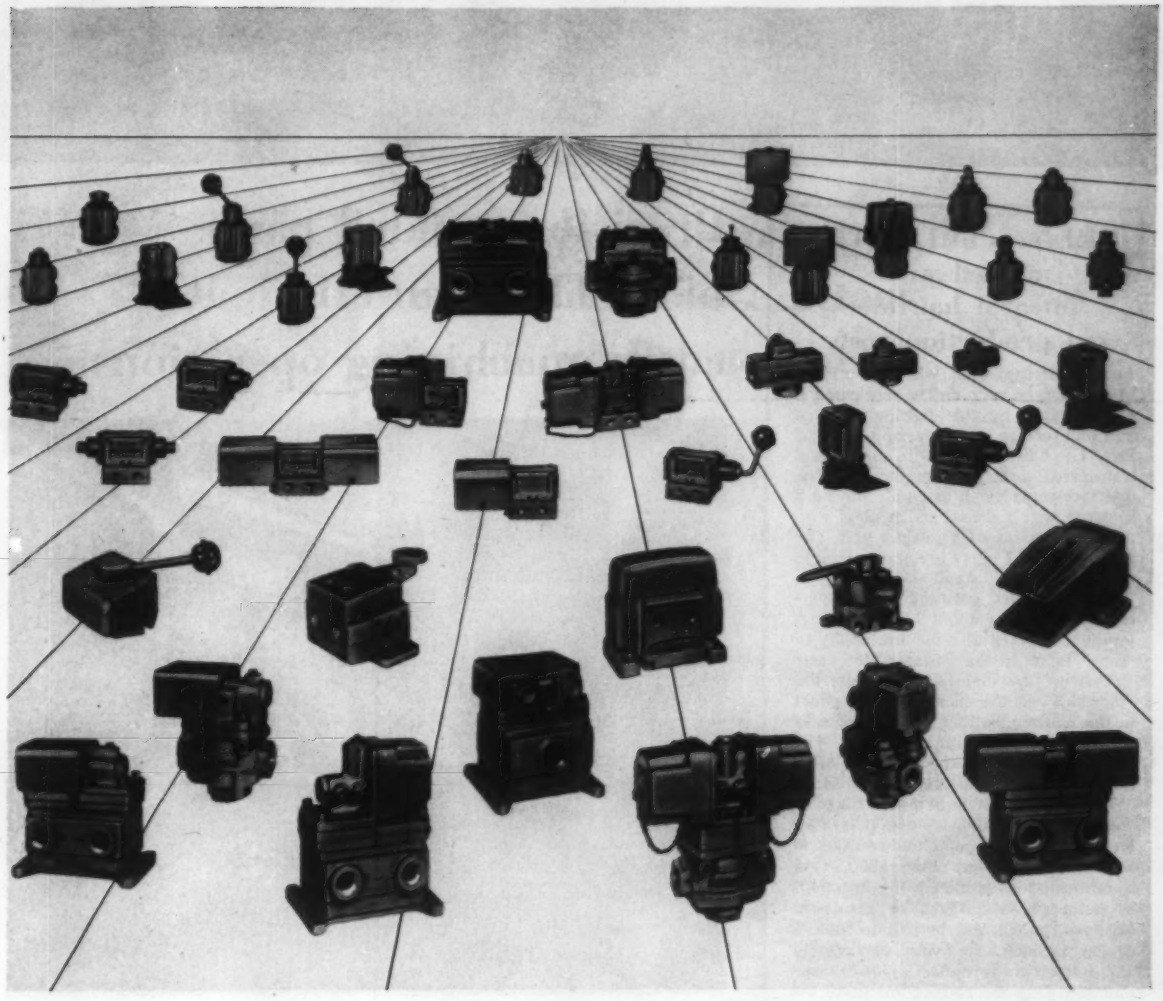


These valves like tough jobs

Discriminating engineers are finding that out. More and more of them are specifying Hannifin valves for every kind of directional air control—including the really tough jobs.

There are plenty of reasons why: Inspired simplicity of design. Fewer parts—and *those* easily and quickly replaceable. Ability to serve a wide range of applications with fewer valve models. And—above all—fast, smooth operation.

Your Hannifin man will gladly give you the whole story. We'll tell you where to get in touch with him—after you examine the big Hannifin catalog.

AIR CONTROL

HANNIFIN

VALVES

***For this complete catalog** showing all the Hannifin directional air control valves, write to Hannifin Corporation, 515 South Wolf Road, Des Plaines, Illinois.*

DU PONT
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

PRODUCT
LATEST PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS

Dial faces of LUCITE® molded with integral hairline cut production costs

The precision with which Du Pont LUCITE acrylic resin can be fabricated is demonstrated by this hairline molded into one surface of a potentiometer dial face. The hairline is a half-round recess transferred directly from the die. The dial face replaces an assembly having a soldered wire hairline and a glass window, at a saving of $1.80 per unit. The parts made of LUCITE are economical to fabricate and withstand shock.

LUCITE offers outstanding transparency, transmitting about 92% of impinging light. LUCITE also has the ability to "pipe" light. In this instance, the clear LUCITE of the dial face transmits the "darkness" of the encasing black panel to the hairline, so that it is unnecessary to fill the hairline with black paint. The dial faces have been in service for more than two years with satisfactory results.

LUCITE is available in a wide range of sparkling, non-fading colors. It is shatterproof, light in weight, and resistant to weathering and many chemicals. LUCITE is fabricated economically by injection- or compression-molding, or extrusion. Du Pont LUCITE may be able to solve a design problem for you, particularly where high-grade optical qualities are required. Clip the coupon for more information about LUCITE acrylic resin.

This portable potentiometer, employed as a millivolt indicator, is manufactured by Leeds & Northrup Company, Philadelphia, Pennsylvania. Inset shows dial face of Du Pont LUCITE acrylic resin used in the instrument.

Precision molded parts of ZYTEL® can eliminate costly machining operations

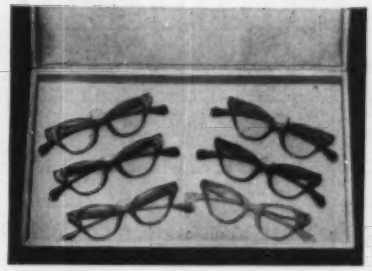
"Likwidurn" soap dispenser manufactured by American Dispenser Company, Inc., New York, New York. Replacement of stainless-steel parts in valve assembly with parts of ZYTEL nylon resin afford substantial cost reductions.

Parts of ZYTEL nylon resin feature a high degree of durability, a low coefficient of friction, and good chemical resistance. Products molded of Du Pont ZYTEL are tough and strong, even in thin sections. They have excellent form stability at temperatures as high as 250°F. Cost savings are possible in many applications because components of ZYTEL usually require no secondary finishing. Frequently, a single part molded of Du Pont ZYTEL can replace an entire complex assembly.

The "Likwidurn" soap dispenser, shown above, is designed to deliver a measured amount of liquid soap at each stroke of the valve. Accurate fit of the valve parts is essential to assure proper operation. The valve must also remain unaffected by the concentrated soap solution.

ZYTEL nylon resin was chosen for this application, because it is economical to mass-produce parts injection-molded to close tolerances, which need no further finishing. The use of ZYTEL eliminates machining of the stainless steel, effecting substantial savings in manufacturing costs. In addition, the weight of the unit is reduced.

Evaluate ZYTEL in terms of your own design needs. Property and application data are available without obligation.

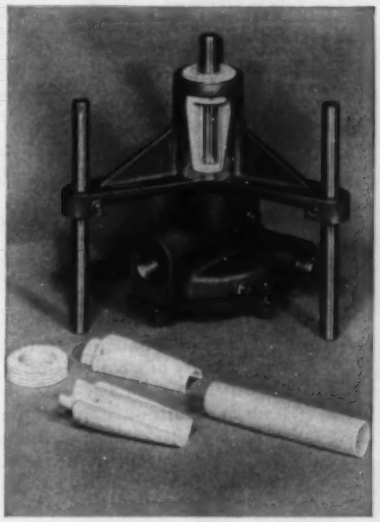


Nylaire – frames of ZYTEL® feature exceptional strength . . . attractiveness

Styled eyeglass frames of ZYTEL nylon resin withstand hard usage without breaking, combine attractive design with durability. ZYTEL can be molded in colors, so frames are offered in a selection of 34 permanent shades.

Fashion-conscious purchasers are pleased by smoothness, resiliency, and light weight of ZYTEL. Du Pont ZYTEL is distinguished by its toughness, form stability, and chemical resistance. These eyeglass frames are one interesting application of ZYTEL, which utilizes a number of the properties of this versatile engineering material. The use of ZYTEL may solve a design problem for you. (*Nylaire* eyeglass frames are manufactured by *Limited Editions, Inc., Linden, New Jersey.*)

High-speed bearing of TEFLON® resists corrosive attack, needs no lubrication



Cutaway portion of submersible pump shows bearing assembly of durable TEFLON tetrafluoroethylene resin. Assembly consists of shaft sleeve, tapered bearing, and lock nut. (The pump shown above is manufactured by ECO Engineering Company, Newark, New Jersey.)

A new bearing assembly of TEFLON tetrafluoroethylene resin has greatly broadened the range of applications of this chemical sump pump.

Due to the inherent surface "slipperiness" of TEFLON (kinetic coefficient of friction of only .04), no auxiliary lubrication of the bearing is necessary. Contamination of pharmaceuticals and sensitive materials by contact with lubricants is therefore prevented.

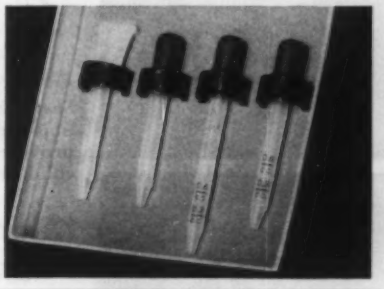
TEFLON is tough and durable. This permits the pump bearing to withstand high radial and tangential stresses at speeds of 3,540 rpm or higher for extended periods of time. The bearing is capable of continuous operation in the presence of product suspensoids and foreign abrasive matter such as tank scale. Bearings of TEFLON permit either chemical or steam sterilization.

Du Pont TEFLON tetrafluoroethylene resin has outstanding chemical inertness. This engineering material is not affected by aqua regia or other acids. Alkalies in any concentration do not react with it. TEFLON is inert to nearly all chemicals and solvents normally used in commercial practice. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect TEFLON.

Du Pont TEFLON offers a distinctive combination of mechanical, electrical, and chemical properties. Use of TEFLON has frequently resulted in more efficient, economical, and compact designs. In your applications, too, TEFLON may be the means of economizing on materials and costs or solving a tough design problem. For more details on how TEFLON can help you, clip and mail this coupon.

DROPPERS ARE UNBREAKABLE

Medicine droppers with unbreakable pipettes made of ALATHON® polyethylene resin give a regulated-size droplet. Lines can be printed on the pipette to indicate dosage. Smooth, highly transparent ALATHON reduces danger of injury to delicate tissues from accidental movements. (Made by PharmaPlastics, Inc., Baltimore, Maryland.)



NEED MORE INFORMATION?

For further details that will help you evaluate these Du Pont engineering materials for use in your product development programs, mail the coupon at left.

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Please send me more information on the Du Pont engineering materials checked: ☐ ZYTEL; ☐ ALATHON; ☐ TEFLON; ☐ LUCITE. *I am interested in evaluating these materials for:*

NAME _____ POSITION _____
COMPANY _____
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TYPE OF BUSINESS _____

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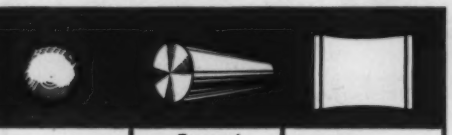
for heavy-duty shock load service...

which bearing is best?



	Ball	Tapered Roller	Shafer
Low Friction Loss	✓		✓
Self-Alignment	✓		✓
High Radial Load Capacity		✓	✓
High Thrust Load Capacity		✓	✓
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Long Life		✓	✓
Fast, Positive Adjustment			✓
Lowest First Cost	✓		
Lowest Over-All Cost			✓

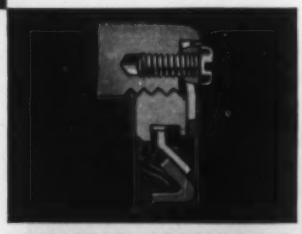
SHAFER Self-Aligning Roller Bearings give you more

Inner race is segment of a ball.

Roller presents matched curve surface.

Shafer design combines both the low rolling friction of a ball and the high load carrying capacity of a roller. Under shock loads, continuous heavy-duty loads—even under conditions of misalignment—Shafer Bearings maintain full load capacity. You can get off-the-shelf delivery of standard pillow blocks, flange units, flange cartridge units and take-up and frame units. Call your nearby CHAIN Belt District Office Representative or Distributor.

and...



"Z" seal keeps dirt out ...grease in

Shafer exclusive—"Z" seal is an all-metal, non-rotating, true self-aligning seal that provides positive sealing under severe conditions.

Micro-lock wear adjustment

Shafer exclusive Micro-Lock provides 12-point adjustment compensating for wear or unusual operating conditions.

Get full information on high bearing capacity. Write for catalog 55A.

CHAIN BELT COMPANY

4643 W. Greenfield Ave., Milwaukee 1, Wis.

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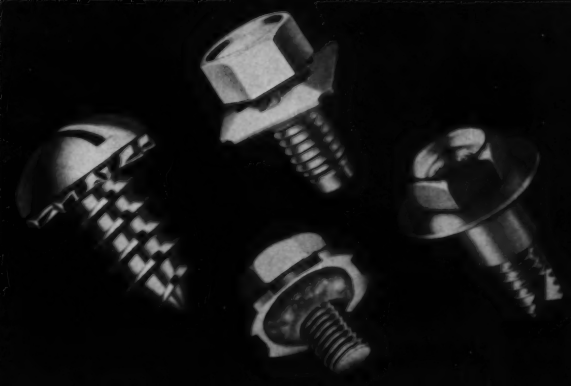
Pre-assembled

to cut your

Costs

...by eliminating handling of multiple parts

SEMS-BY-SHAKEPROOF
Pre-assembled Screw
and Shakeproof® Lock Washer



Even greater cost-savings are possible with Sems-by-Shakeproof through variations in threads, points, heads, and washers, or with the addition of sealing compound or special sleeves.

• You handle one unit instead of two or more with Sems-by-Shakeproof • Every lock washer is factory-matched • Lost and forgotten washers eliminated • Available in variety of screw and lock washer combinations, multiple-piece assemblies and with mastic sealants.

Send for Sems-by-Shakeproof sample kit today

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DIVISION OF ILLINOIS TOOL WORKS

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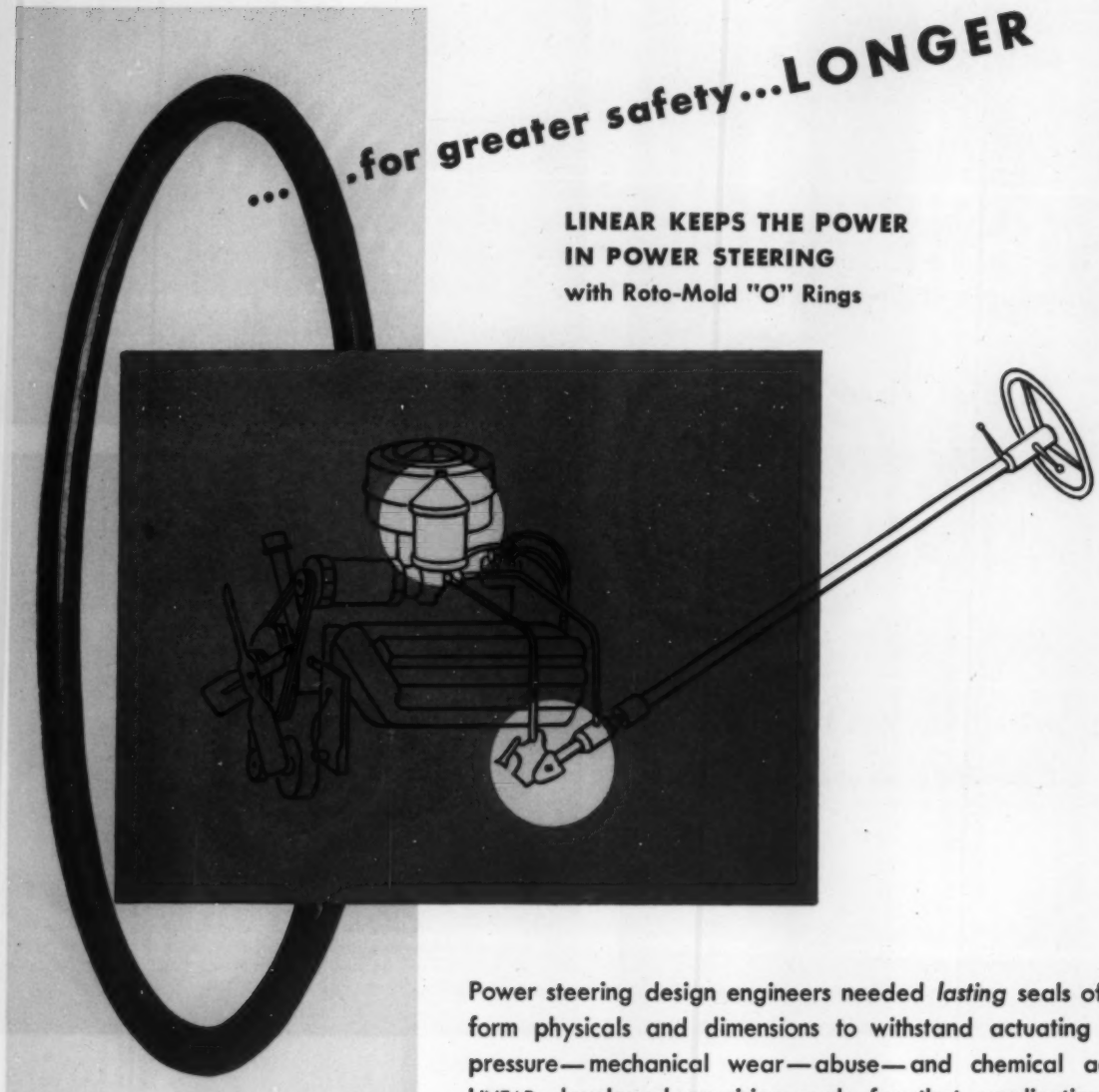
Circle 455 on page 19

. . . for greater safety . . . LONGER

LINEAR KEEPS THE POWER IN POWER STEERING
with Roto-Mold "O" Rings



Power steering design engineers needed *lasting* seals of uniform physicals and dimensions to withstand actuating fluid pressure—mechanical wear—abuse—and chemical action. LINEAR developed precision seals for that application—to keep the power in power steering.

LINEAR'S ability to produce precision "O" rings in the most modern elastomers has helped solve a wide variety of sealing problems involving extreme ranges of temperature, pressure and destructive fluids. The exclusive Roto-Mold process assures top quality production—maximum economy—fast delivery schedules.

When it's a sealing problem, call on LINEAR or one of its agents for engineering assistance—and be sure to specify LINEAR Roto-Mold "O" Rings.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA.

Circle 456 on page 19

Ramjet tailpipes withstand severe abuse. (*Photo courtesy Marquardt Aircraft Company*)

MULTIMET Alloy Controls the Blast of Ramjet Engines

Tailpipes used to direct the searing blast of power in today's ramjet engines must withstand temperatures in excess of 2000 deg. F, plus severe vibration. High-speed ramjets operate in the neighborhood of 1500 mph. At these high speeds, vibration is almost as serious a threat to tailpipe life as heat. Because of its strength at high temperatures, MULTIMET alloy has given good service in tailpipes that vibrate as much as three inches.

Ramjet tailpipes are made of MULTIMET alloy sheet that is only 0.051 to 0.078 in. thick. The combined high-temperature strength and oxidation resistance of MULTIMET alloy permits the use of lightweight tailpipes with good heat-transfer properties.

MULTIMET alloy is one of many HAYNES alloys capable of extending the life of parts used at high temperatures. For literature describing the properties of HAYNES high-temperature alloys, get in touch with the nearest Haynes Stellite Company Office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

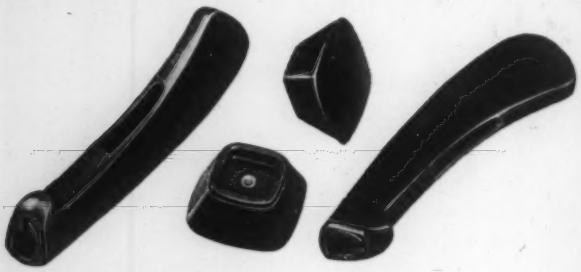
General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" and "Multimet" are registered trade-marks of Union Carbide and Carbon Corporation.

When one of many requirements

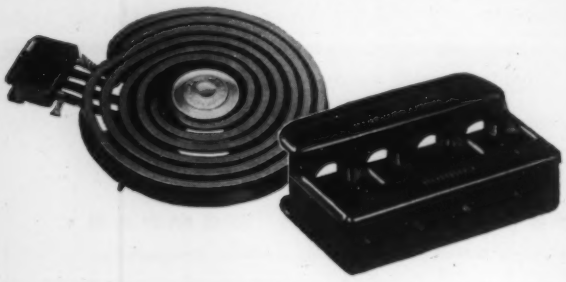


Heat resistance with **HIGH STRENGTH**

High strength-to-weight ratio permits slimness in design, a style feature in handles of Bridgeport Brass Company's "Copperware" skillets and saucepans.

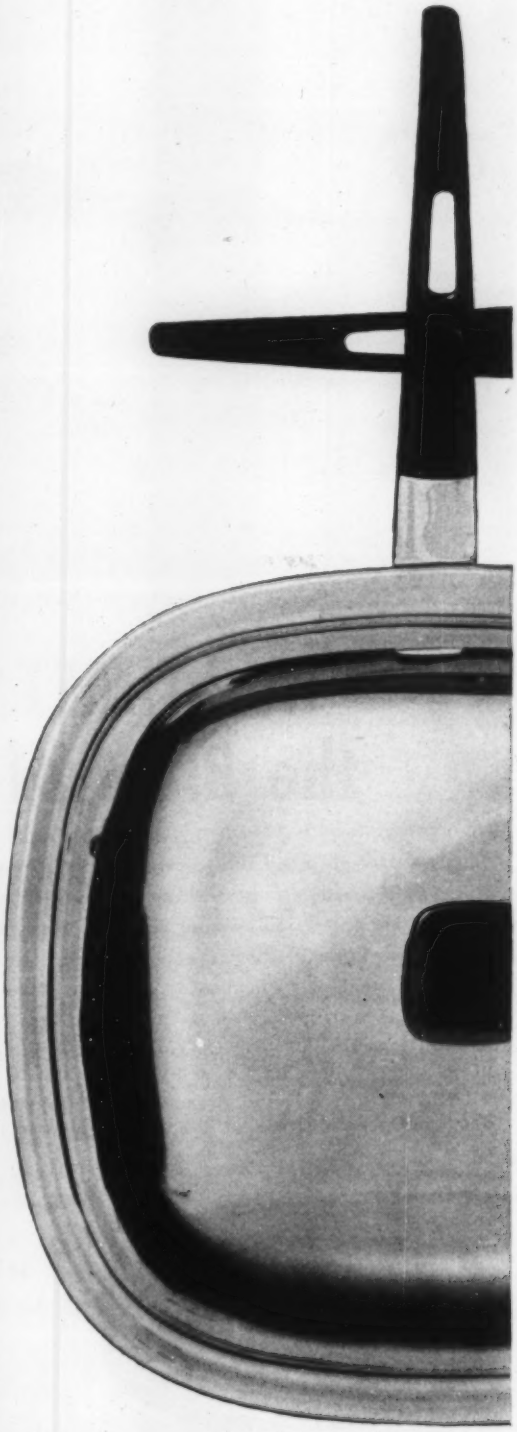
Heat resistance plus **DURABLE SURFACE LUSTER**

Glossily reflecting highlights, the Duncan Hines Tea-O-Mat's handle of molded Durez has lustrous beauty that will not fade.

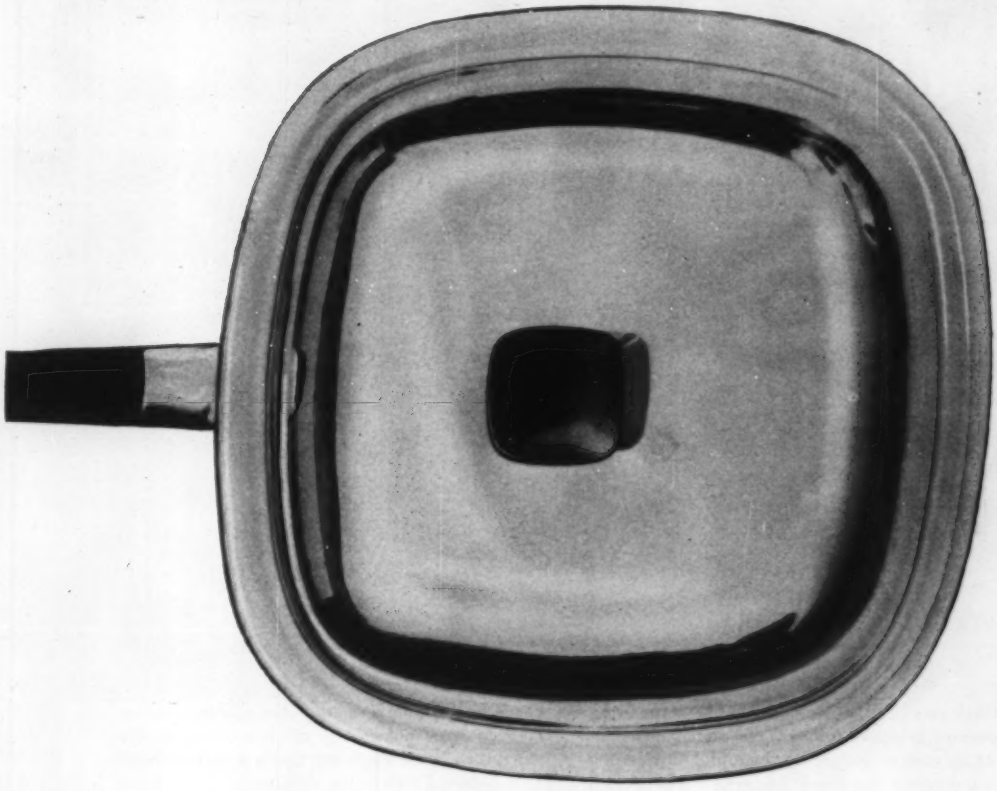


Heat resistance plus **EXCELLENT ELECTRICAL PROPERTIES**

Dependable service in everyday use is safeguarded by Chromalox Microtube terminal blocks of Durez phenolic in these slim-tube range units.



is HEAT RESISTANCE



get the others too...with

DUREZ PHENOLICS

Solutions to three separate problems furnish a graphic example of why engineers turn to the reliable Durez thermosetting phenolics when planning new products or improving current models. In all three, heat resistance happened to be a basic requisite. Yet each required a different combination of other properties from the other two for success.

For more than thirty-five years Durez has been a gold mine of useful properties for the designer. In close-tolerance components resistant to impact, high and low temperatures, water, and chemicals... and wherever good electrical characteristics are essential... you can usually do it better with Durez. These materials also help you hold the cost line, due to their uniformity and excellent molding behavior. Many are designed for easy preforming and molding in automatic machines.

For data and for information on new developments in these versatile plastics, keep in touch with your molder... call on our field engineering service... or let us send you "Durez Plastics News."

DUREZ®

Phenolic Plastics that Fit the Job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

504 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

Circle 458 on page 19

NEW HAMMARLUND RADIO RECEIVER

FEATURES DIE CAST PANEL

CASE HISTORIES FROM MT. VERNON FILES

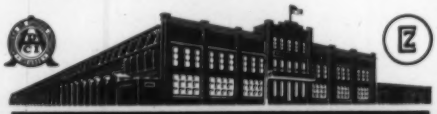
In their new HQ-100, Hammarlund Manufacturing Company brings to reality a completely new concept in receiver design. It is beautiful. It gives the radio amateur the utmost in performance. And it sells for far less than other comparable short-wave receivers.

A chief reason for this great economy is the front panel—the first die-cast panel in the history of commercial radio equipment. This 3-dimensional, channeled die-cast aluminum panel is used because it affords both rigidity and great structural strength. To produce its equivalent in sheet metal —the currently used method in the industry—*would cost 4 times as much.*

This remarkable panel is the result of thorough collaboration between Hammarlund and the die-making experts at Mt. Vernon, who made practical suggestions which simplified its design.

In addition to the production economies of die casting, the panel benefits from these other important advantages: (1) Die casting's inherent accuracy enables Hammarlund to assemble the chassis with what they call "camera precision construction." (2) All rejects on the production line are eliminated. (3) In finishing—die casting enables them to work out clearly divided areas for the elegant two-tone treatment that is both functional and beautiful. Also, the amount of finishing is minimized.

When you are out to break precedent, as Hammarlund did, you too can find the kind of skilled help you need in the complete service available from Mt. Vernon's coordinated designing, die-making, casting, and machining facilities, all under one roof, which can supply die cast zinc and aluminum parts ready for use. A switch to a die casting service like ours may be your next step. Let's discuss it.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

SALES REPRESENTATIVES

Mr. Grant Eller
6 East 194th St., Cleveland, Ohio

Mr. Jerome J. Theobold
9 East Genesee St., Skaneateles, N. Y.

Mr. Arthur Diamond, Tools Incorporated
86 Bethlehem Pike, Philadelphia, Pa.

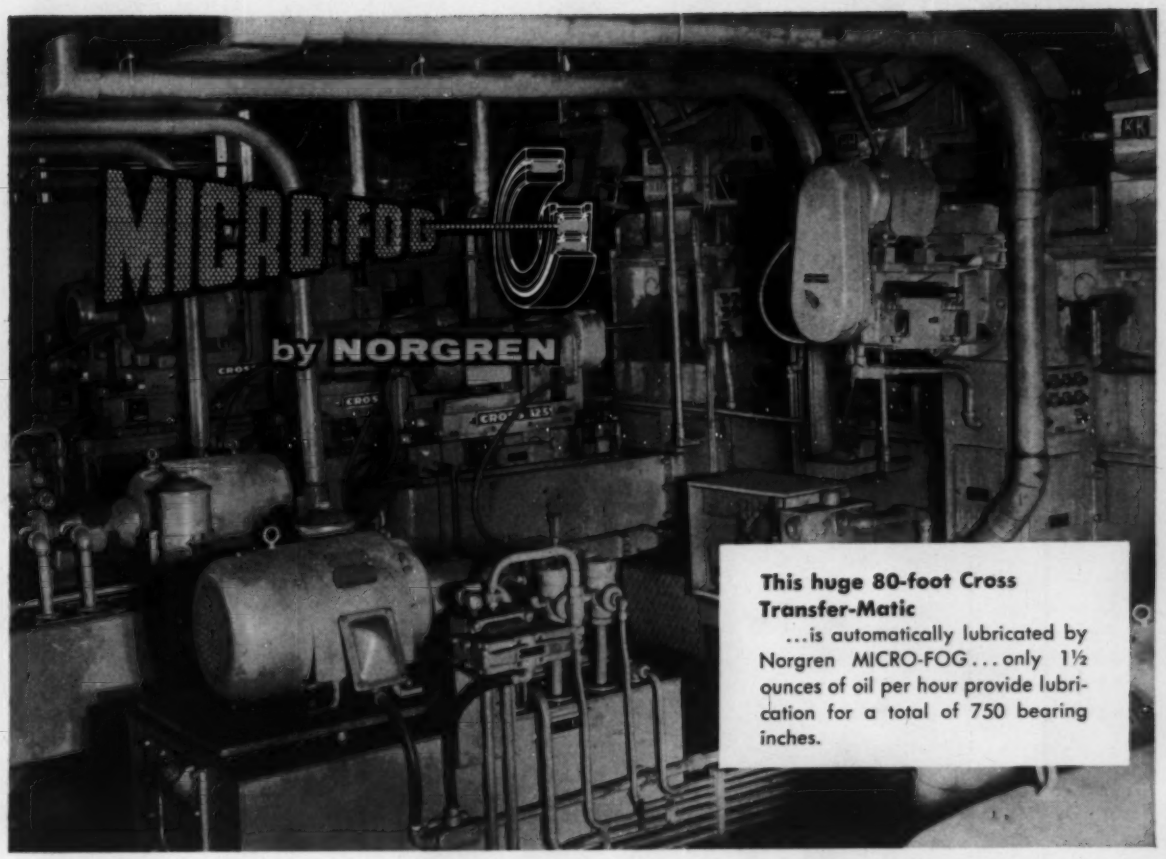
Mr. Anker Anderson
Cascade Road, Stamford, Connecticut

Mr. William Sauers
101 Briarcliff Road, Rochester, N. Y.

Mr. David King
230 Grant Boulevard, Syracuse, N. Y.

Mr. George E. Hahl
39 South Munn Ave., East Orange, N. J

Circle 459 on page 19



This huge 80-foot Cross Transfer-Matic

...is automatically lubricated by Norgren MICRO-FOG... only 1½ ounces of oil per hour provide lubrication for a total of 750 bearing inches.

AUTOMATIC *Air-Borne* LUBRICATION

for Bearings, Gears, Chains, Cams, Slides, Ways

How Much Oil is REALLY Needed to Lubricate?

The only oil that lubricates is the thin film that separates the metal surfaces. Any additional lubricant is a waste and may even be harmful, causing over-heating due to fluid friction. With intermittent systems, there may be periods when there is not enough oil—and metal wears against metal.

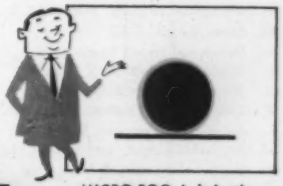
Norgren MICRO-FOG Provides Optimum Lubrication

One MICRO-FOG Lubricator automatically coats all the bearings, gears, chains and other components of a machine with a continuous, protective film of fresh oil. Just the right amount of oil—no more, no less—is continuously applied to provide the most efficient lubrication, reducing wear on machine components and cutting maintenance and replacement costs.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR NEW NO. 800 CATALOG.

TOO MUCH OIL—
Hot bearings due to fluid friction.

TOO LITTLE OIL—
Bearings run hot, wear excessively.

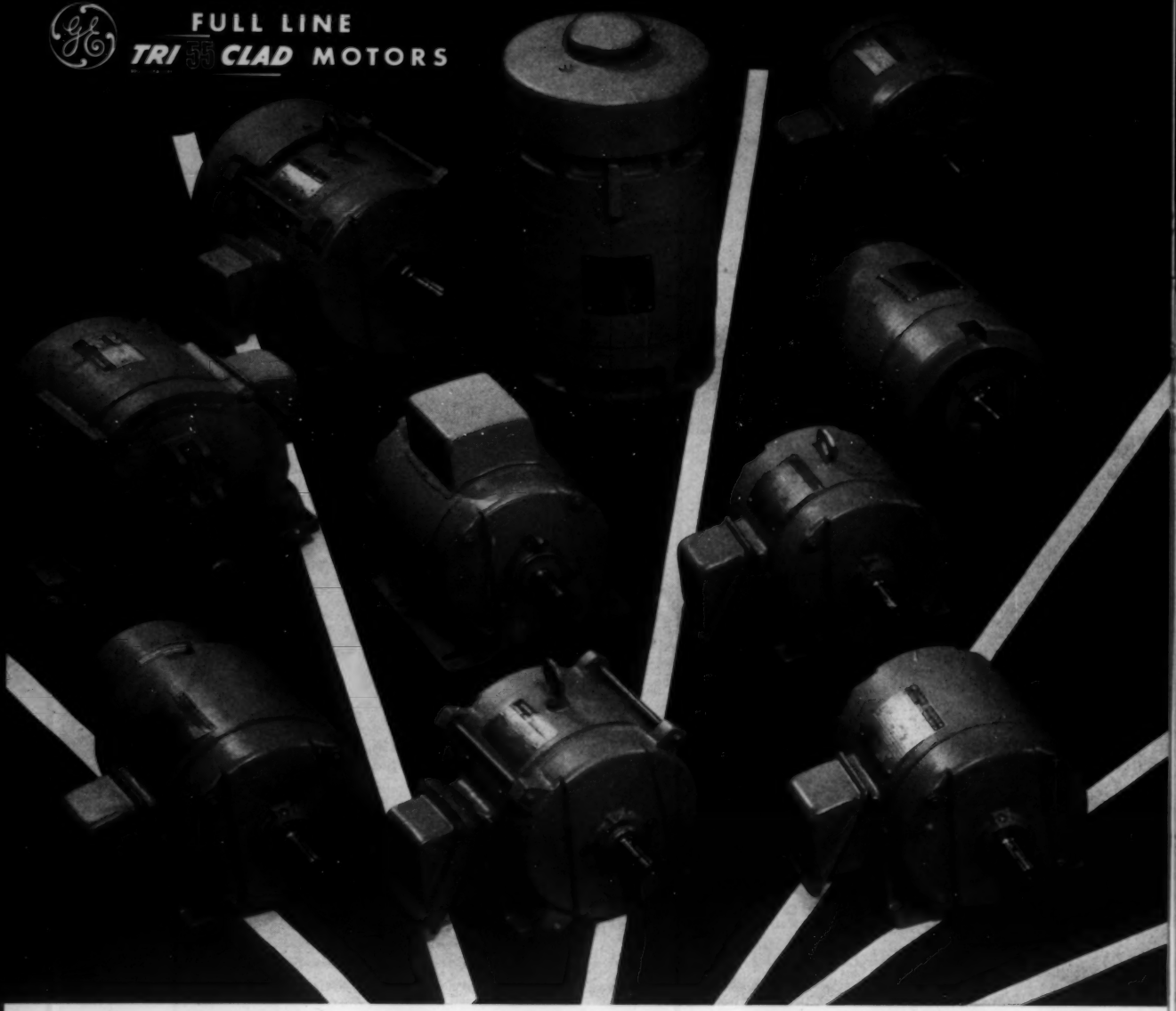


MICRO-FOG Lubrication—
Always just the right amount of fresh oil.

C. A. NORGREN CO.

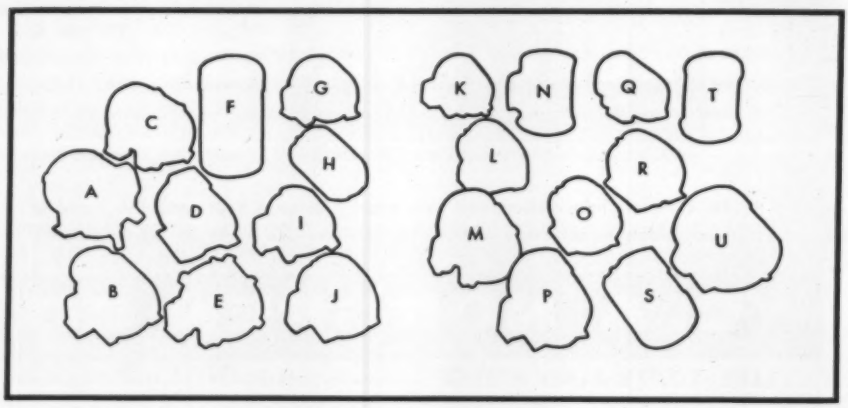
3442 SOUTH ELATI STREET ..... ENGLEWOOD, COLORADO

FULL LINE
TRI-CLAD MOTORS



THE MOTOR YOU NEED

A. Clutch-brake, dripproof, 2-3φ
B. Brake-motor, 2-3φ
C. Explosion-proof, fan-cooled, 2-3φ
D. Dripproof, resilient-base, 1φ
E. Explosion-proof, non-vent., 2-3φ
F. Vert. hollow-shaft, P-base, 2-3φ
G. Loom motor, 2-3φ
H. Dripproof, round frame, C-face, 2-3φ
I. TENV, standard-duty, 2-3φ
J. Standard dripproof, 2-3φ
K. Close-coupled pump, C-face, 2-3φ
L. Standard dripproof, 1φ
M. Explosion-proof, fan-cooled, 1φ
N. Vert. solid-shaft, P-base, 1φ
O. Enclosed, air-over, 2-3φ
P. TEFC, severe duty, 2-3φ
Q. Standard TEFC, 1φ
R. Dripproof, resilient-base, 2-3φ
S. Dripproof, round-frame, C-face, 1φ
T. Vert. solid-shaft, P-base, 1φ
U. TEFC, standard duty, 2-3φ



IS IN THIS PICTURE

Now! You never have to take *less* than General Electric Tri-Clad 55 motor quality—because G.E. now offers you a *complete line* of Tri-Clad 55 motors to assure you of a perfect match of motor to machine.

In most cases, you'll choose the rugged, versatile Tri-Clad 55 standard motors (single- or polyphase, dripproof or enclosed). For those special industry applications, General Electric also offers you a full line of industry-specified motors (for example, end-mounted, built-in motors for the pump and machine tool industries).

Of course, all Tri-Clad 55 motors incorporate these extra-value features: Mylar* polyester film insulation for longer motor life, minimum maintenance; silicone coating on the motor stator assembly for maximum protection against failure due to moisture; Formex† magnet wire insulation for protection against heat-aging and abrasive dusts; non-wicking leads; more rigid construction; easier installation and servicing; and many, many more.

For expert engineering assistance in selecting the right G-E motor for your application, contact your nearby G-E Apparatus Sales Office. Or, for more information about General Electric's full line of Tri-Clad 55 motors, write: General Electric Co., Section 840-6, Schenectady 5, N. Y. and ask for bulletins GEA-6240 and GEA-5980.

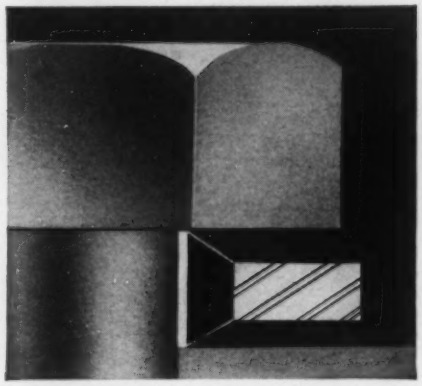
†Reg. trademark of General Electric Co. *Reg. trademark of DuPont Co.

GENERAL ELECTRIC

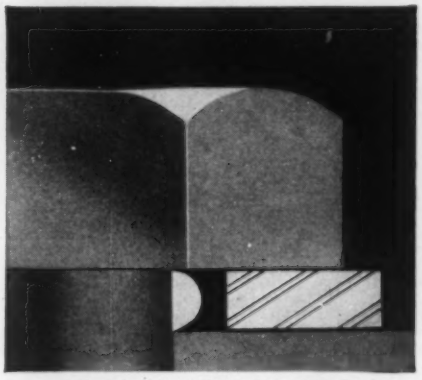
Circle 461 on page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Seal before compression



When bolt is tightened, sealing lips are forced against surface.

Hycar rubber bonded to steel solves sealing problems

FACED by a sealing problem with water, gases, chemicals, petroleum products or other fluids? Then listen to this:—

The Precision Rubber Products Corporation of Dayton, Ohio, has come up with a one-piece seal using Hycar nitrile rubber that gives positive sealing action against constant or pulsating pressures up to 10,000 psi!

The Hycar is heat and pressure-bonded to a steel washer to become the sealing member. When compressed, it supplies lock washer action and reduces bolt torque. Under any type of flange, bolt or screw, it gives leak-proof sealing. What's more, it eliminates costly groove cutting or machining of surfaces.

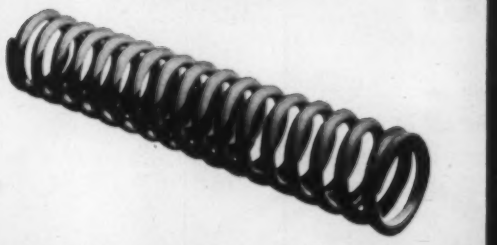
Hycar was specified for this new product because it keeps its shape, strength and flexibility . . . is far superior to general purpose rubber in resistance to oxidation and aging. And it has exceptional resistance to the deteriorating properties of a wide range of fluids and gases, temperatures and pressures.

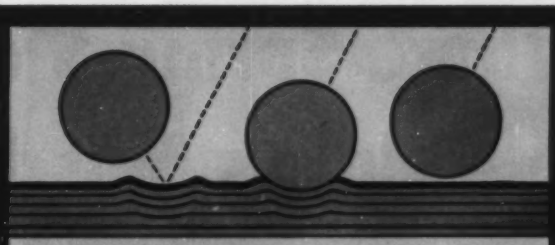
Throughout industry, Hycar's remarkable qualities are improving existing products or are providing the inspiration to create new products. For complete information on how one of the Hycar rubbers can do this for you, too, write Dept. HK-2, B. F. Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
Reg. U.S. Pat. Off.
American Rubber

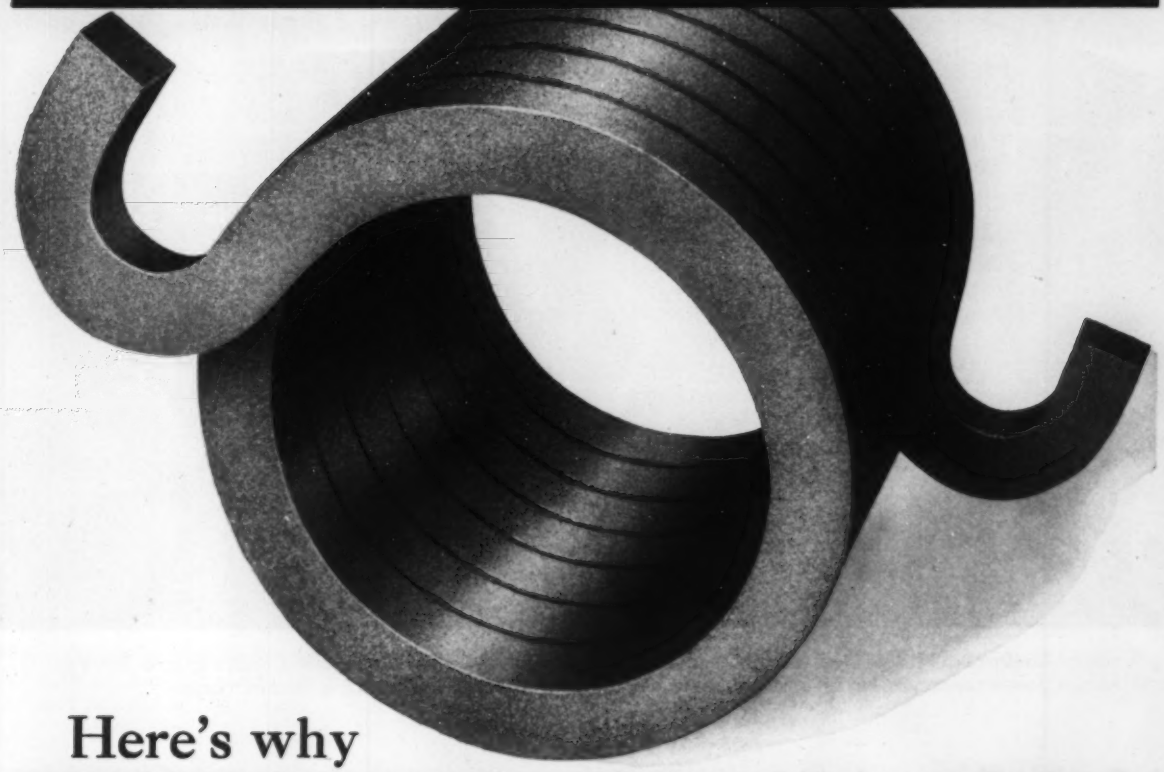
B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors





WHAT SHOT PEENING IS. Thousands of round steel shot are projected against the spring surface at high velocity. They create a thin, cold worked layer that, in effect, causes the spring to operate at lower stress. What's more, shot peening erases tiny surface imperfections which could cause stress concentration points leading to spring failure.



Here's why

CRUCIBLE FATIGUE RESISTANT SPRINGS

can withstand higher stresses

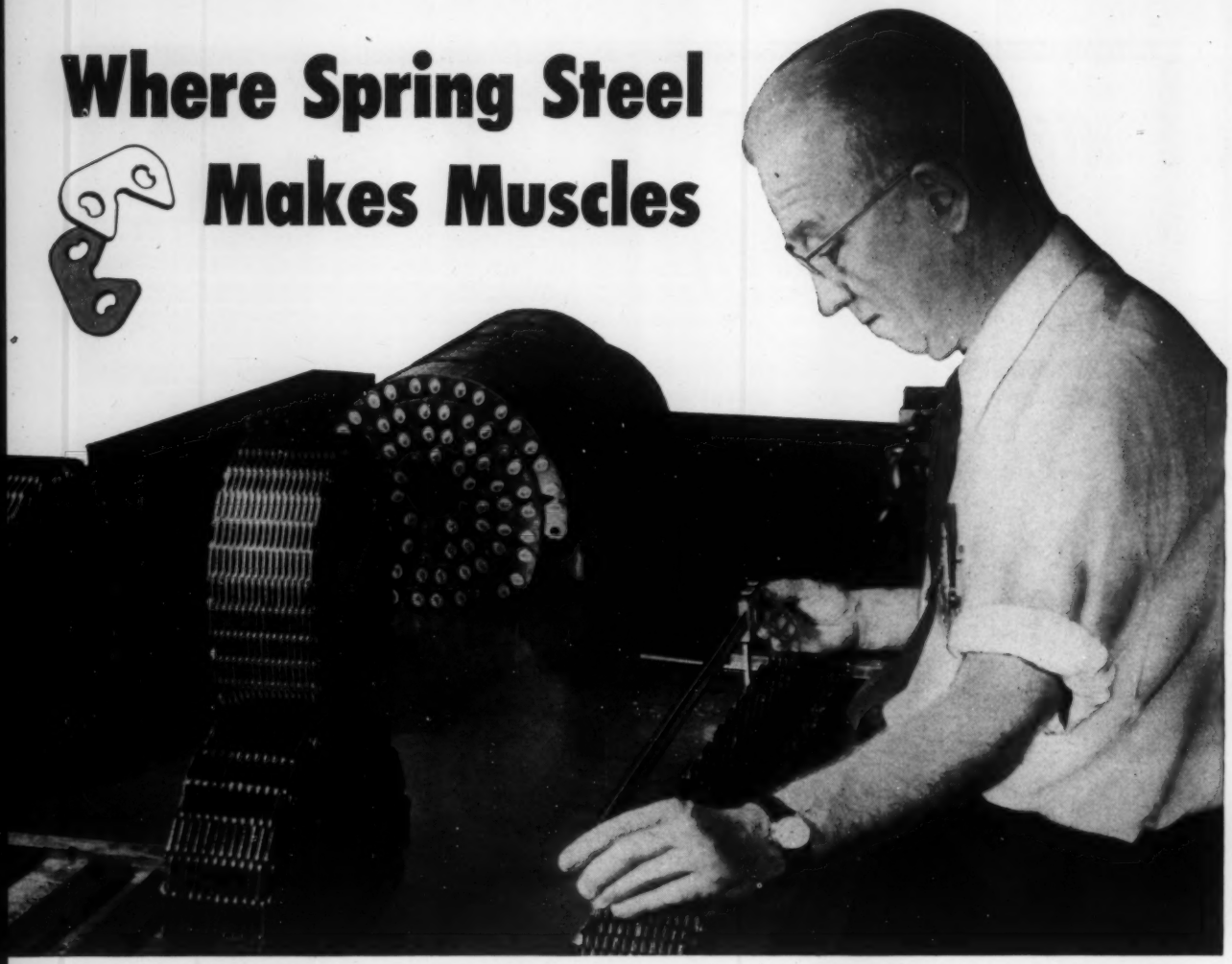
Every Crucible *fatigue resistant* spring for heavy-duty industrial applications is shot peened for higher strength and greater fatigue resistance. Crucible controlled shot peening imposes a negative stress on the surface that offsets positive stresses set up in service. Result: a truly *fatigue resistant* spring that outlasts conventional ones.

Good springs are a combination of proper design, skilled workmanship and fine steel. When you buy Crucible springs you employ a staff of proven designers and spring makers, and Crucible's years of experience in fine steel making—from ore to finished springs. Let an experienced Crucible spring specialist suggest the best *fatigue resistant* spring for your application. Or write for a copy of the "Handbook of Coil Spring Design." *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE spring division

Crucible Steel Company of America

Where Spring Steel Makes Muscles



Uniform quality of steel from Thomas Strip Division, used for links on Morse Chain's rugged Hy-Vo power transmission drive, shows up as assembled chain is checked with a Vernier Gauge.

▶ Quality Thomas Strip Scores High As Links for Morse Chain's Rugged Hy-Vo

Because Morse Chain Company's Hy-Vo Chain transmits more power per inch of width than any conventional chain, it handles some of industry's toughest jobs.

And Hy-Vo can do its power transmission jobs at speeds up to 90 miles an hour.

There's a job in the oil fields, for example, that demands the kind of muscles Hy-Vo has—muscles that Pittsburgh Steel Company's Thomas Strip Division builds into Hy-Vo's durable links.

This tough oil field application requires a rugged four-inch wide power chain to transmit maximum horsepower to pumps operating at pressures up to 10,000 psi.

Thanks to precision engineering at Morse Chain and uniform quality steel, Hy-Vo takes this punishment in stride.

To make such a dependable, trouble-free power chain drive, Morse Chain—a division of Borg-Warner—buys the best steel made.

That's why tons of quality, cold rolled, high carbon spring steel strip from Thomas Strip are shipped each month to Morse Chain's Ithaca, N.Y., plant. Each coil must meet Morse Chain's demand for strip that has:

• **Punchability and Shearability** which show up on Morse high speed piercing and blanking presses making the chain links.

Uniform quality in the strip adds to the number of strokes possible before tools must be reground or sharpened.

Norman Bremer, chief engineer at Morse, underscored the importance of longer tool life when he declared: "The more strokes we get between grinds, the lower our operating expenses."

• **Holding Tolerances** from shipment to shipment and from coil to coil. A foot length in any of the four sizes of the Hy-Vo can vary only from zero to plus 15 thousandths of an inch.

Even minute variations in thickness on each of the links that make up a width of Hy-Vo chain are enough to cause excessive stack-up in the assembly of the chain. Result: a rejected chain.

What's more, in a given length of Hy-Vo chain there are hundreds of links and many pins which require extremely close tolerances.

"Our experience with Thomas

Sample coils of Thomas Strip are taken to the Morse Metallurgical Lab for checks on chemical analysis.

Punchability and shearability qualities of Thomas Strip appear as coil is fed into a piercing and blanking press.

After links are blanked, tolerances on hole sizes are checked closely so that pins joining links will fit snugly.

Careful hand assembly of each Hy-Vo Chain follows after heat-treating and blackening of links. Fine grain cold rolled spring steel from Thomas Strip prevents undersize holes and excessive burrs.

Strip's ability to meet our rigid tolerance requirements has been very satisfactory," said Ted Sharp, Mr. Bremer's assistant. Just as it does in any application . . . including fasteners, springs or automotive parts. . . . Thomas cold rolled high carbon strip gives Morse these advantages:

• **Hardenability** that shows up during the rapid fire piercing and blanking operations. Too soft or too hard strip boosts the rejection rate and takes its toll of costly tools.

This is especially important because Hy-Vo Chain must meet an average ultimate tensile strength of 20,000 pounds per inch of pitch and width.

• **Uniformity in Micro-structure** adds to tool life and aids cleanliness in piercing and blanking links.

• **Standard Size Coils** of Thomas Strip's spring steel keep production humming and orders filled for Morse customers. Small size coils slow up the production pace because machines have to be stopped for each new coil.

If your product requires high carbon spring steel, you can duplicate the benefits Morse Chain Company gains through using Thomas Cold Rolled Strip. Whatever your needs for top quality steel strip specialties it will pay you to consider Thomas Strip. It's available plain or already coated with zinc, copper, brass, nickel, lead alloy or tin in a wide variety of finishes.

Get in touch today with Thomas Strip through any district sales office listed below. Trained engineering help is available to help solve your production problems. Call now.

Thomas Strip
DIVISION

Pittsburgh Steel Company

Grant Building **Pittsburgh 30, Pa.**

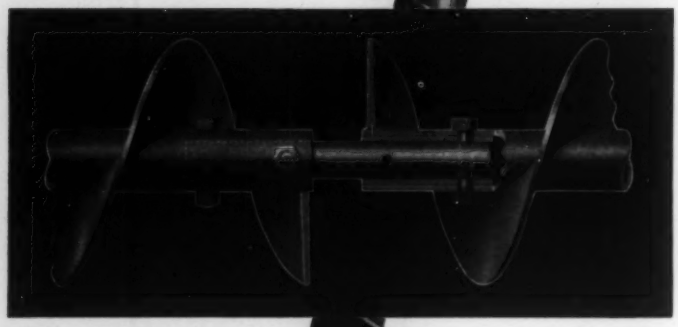
District Sales Offices

Atlanta	Columbus	Detroit	New York	Tulsa
Chicago	Dallas	Houston	Philadelphia	Warren, Ohio
Cleveland	Dayton	Los Angeles	Pittsburgh	

Circle 464 on page 19

JEFFREY SPIRAL CONVEYORS

are built for your particular engineering



Jeffrey maintains close tolerances on spiral pitch and diameter; accurately machines the pipe and internal collars to avoid looseness.

No wiggle or wobble to cause extra wear

YOU CAN design Jeffrey spiral flights and conveyors into your heavy duty, finer products with complete confidence. Spirals are built to close tolerances of pitch and diameter, alloys selected for maximum life. Conveyor pipe and internal collars are accurately machined so there will be no wiggle or wobble to cause early depreciation.

The high quality of Jeffrey spiral conveyors contributes to the dependability which you design into your products.

Jeffrey engineers offer data and assistance to designers who are laying out machines which include conveying operations—help in selecting metals and alloys best suited to handling corrosive or abrasive products—types of spirals best suited for transferring and mixing.

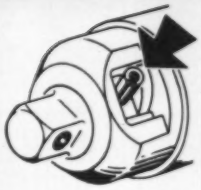
For answers to your conveying problems, write The Jeffrey Manufacturing Company, Columbus 16, Ohio.

JEFFREY

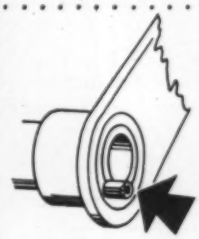
CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

Circle 465 on page 19

Rollpin® replaces 12 different fasteners



REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet wrench adaptor. With its light weight and high shear strength, Rollpin functions perfectly . . . cuts assembly costs.

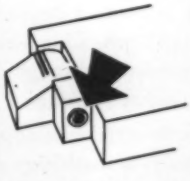


REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

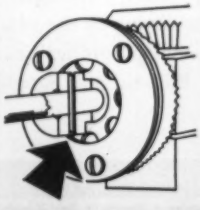
REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.

REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.

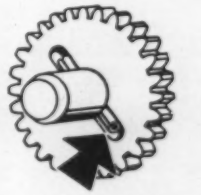


REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.

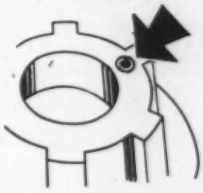


REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.

REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.

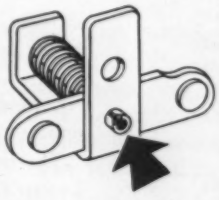


REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.

REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

WHERE CAN YOU USE THIS SIMPLE FASTENER?

Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

Drives easily into standard holes, compressing as driven. Spring action locks it in place—regardless of impact loading, stress reversals or severe vibration. Rollpin is readily removable and can be re-used in the same hole. Made in carbon steel, stainless steel and beryllium copper. Write for samples and information, ELASTIC STOP NUT CORPORATION OF AMERICA, 2330 Vauxhall Road, Dept. R47-44, Union, New Jersey.

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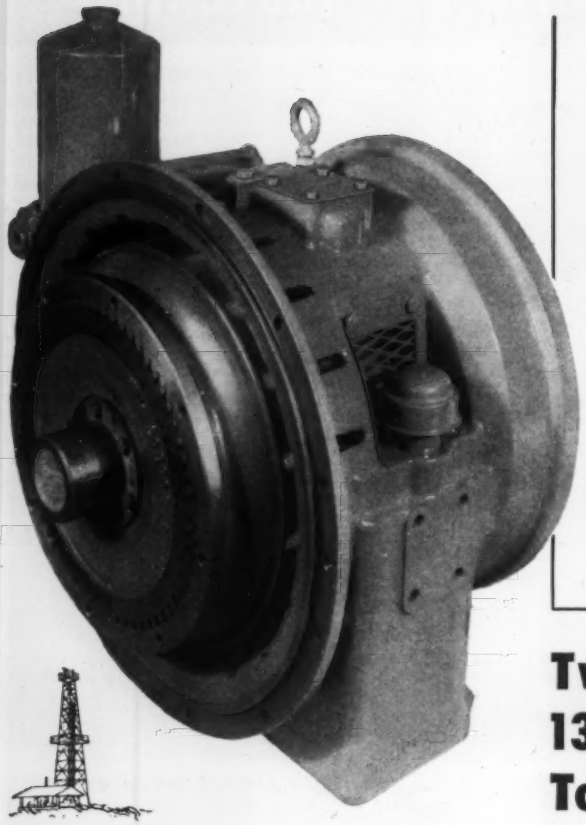
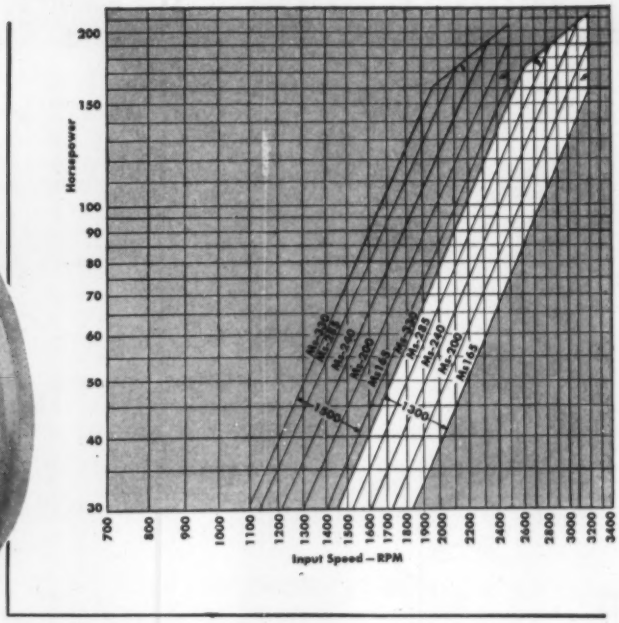
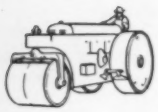
ROLLPIN TRADEMARK

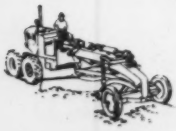
ELASTIC STOP NUT CORPORATION OF AMERICA

2330 VAUXHALL ROAD, UNION, NEW JERSEY









Twin Disc offers new 1300 Series Single-Stage Torque Converters

To meet the growing trend toward higher speed diesel and gasoline engines, Twin Disc Clutch Company announces its new 1300 Series Single-Stage Torque Converters . . . a series that offers ideal torque ratings for shovels, materials handling equipment, small industrial locomotives, front-end loaders, hoisting machinery, road rollers, graders and many similar applications.

The new 1300 Series Single-Stage Torque Converters are rated from 30 hp at 1450 rpm to 212 hp at 3200 rpm . . . with impellers available for specific torque ratings of 165, 200, 240, 285 and 330 pound-feet.

Current production of the 1300 Series consists of one model—the Model "F." This is a spacer-type arrangement with an SAE No. 2 flywheel housing size and either an SAE No. 2 or No. 3 output housing.

Like the Twin Disc 1500 Series Single-Stage units, the 1300 Series has an exclusive blade design which develops a counter-head at high-speed ratios, stopping fluid circulation. This simplifies design and construction and eliminates the need for a free-wheeled stator.

Impellers having different bladings (both number of blades and pitch) are interchangeable, permitting torque capacities to be matched more accurately to engines of various hp sizes and speeds.

The 1300 Series cooling requirements are minimized because of a rotating impeller housing which provides air circulation through the ventilated stationary housing.

If you've been considering a torque converter in your machinery designs, or are dissatisfied with your current single-stage units, investigate today the benefits offered by the new Twin Disc Single-Stage Torque Converters. Write for Bulletin 508 Supplement.

TWIN DISC

TWIN DISC
Torque Converters

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois
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Circle 467 on page 19

MACHINE DESIGN
April 4, 1957

Longhair or Crewcut?

FEW engineers think of themselves as intellectuals, according to a recent survey. Yet "intellectual" means endowed with intellect, brainpower and mental capacity—necessary attributes of any engineer worth his salt.

Perhaps, if he has thought about it at all, an engineer is afraid of being labeled an egghead. But an egghead, we've heard, is merely a person who has been educated beyond his intelligence. He's a pseudo-intellectual and not very important in our scheme of things.

Within our profession are two kinds of genuine intellectuals—symbolized by the longhair engineer and the crewcut engineer. The differences are in direction of education and in motivation, rather than in basic intellect.

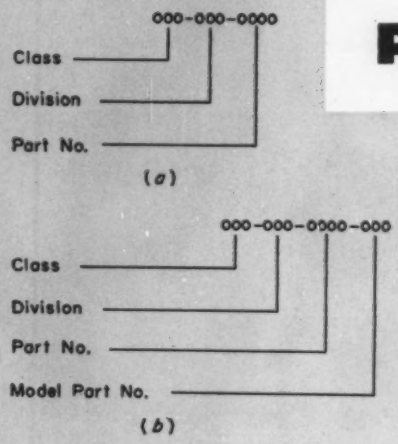
The longhair engineer likes the theoretical, mathematical, scientific approach. He has the education and intelligence to handle difficult problems in fundamental fashion. The crewcut engineer is more interested in making things work. He is the ingenious chap who translates the theory and the visions of the longhair into practical hardware.

Working as a team and with mutual respect for one another's talents, the longhair and crewcut engineers have brought engineering to its present high state of development. That takes brains, and no engineer—longhair or crewcut—should be afraid to let his brains show.

Colin Carmichael

EDITOR

Fig. 1—Numbering system is broken down to show, *a*, class of machine; division, or type within the class; and part numbers which correspond to number of parts, subassemblies or assemblies. Model part numbers, *b*, indicate functional differences of otherwise interchangeable parts.



The part-numbering system described in this article has proved adequate during 50 years of application to an increasingly diversified product line. Setup of the system provides the flexibility essential in an expanding company.

Developing a Part-Numbering System

for present and future requirements

By Everett Woerter
Manager, Standards Dept.
American Machine & Foundry Co.
Greenwich, Conn.

IN THE OVERALL engineering and manufacturing effort, often too little attention is paid to the unglamorous but essential task of selecting a part-numbering system which fits the requirement of the individual company.

Engineering research and development, product improvement and automation have received growing emphasis in industry, and an inflexible part-numbering system is no longer capable of properly accounting for the resulting multitude of drawings and machine parts.

To determine which numbering system will be the most practical and expeditious in the handling of its drawings and tabulations, management must first evaluate its individual product line and consider the extent of its eventual expansion. Only then can it attempt a selection of any one of the various numbering systems available.

An example of a successful part-numbering system in an expanding and diversified company is found at American Machine and Foundry Co. When AMF was founded approximately 55 years ago, the company manufactured machinery for packaging tobacco and making cigarettes. It currently operates 31 manufacturing facilities and 5 engineering laboratories in the U. S. and Canada designing and producing machines for industry, consumer goods, weapons for defense, and nuclear equipment.

A basic principle of the numbering system adopted when the company was founded—that the machine description be a part of the part number—has never changed. For example, parts for the Standard Cigarette Machine were originally numbered S.C.M. 1, S.C.M. 2, etc. In 1924, with the adoption of IBM machines, a numerical class and division type of numbering was substituted for the descriptive symbol or abbreviation.

Class Number: Machines were classified as to type or end product and assigned to a designated numerical class. Examples of some typical product lines and their respective class numbers are:

Class 1—Cigarette making machines
Class 2—Cigar making machines
Class 82—Bowling equipment
Class 83—Wrapping machines

Division Number: Within a given class of machines, different types and variations of types of machines are assigned different division numbers. Division 1 of class 1 indicates the Standard Cigarette machine; division 2, the Chico Cigarette machine; division 3, the Bonsack Cigarette machine; etc. All are cigarette machines, but each produces a different size or shape of cigarette. Other examples of division numbers are as follows:

Class 82, division 8—Radaray
Class 82, division 30—Pinspotter
Class 82, division 32—Ball Lift

With the adoption of the numerical system, a

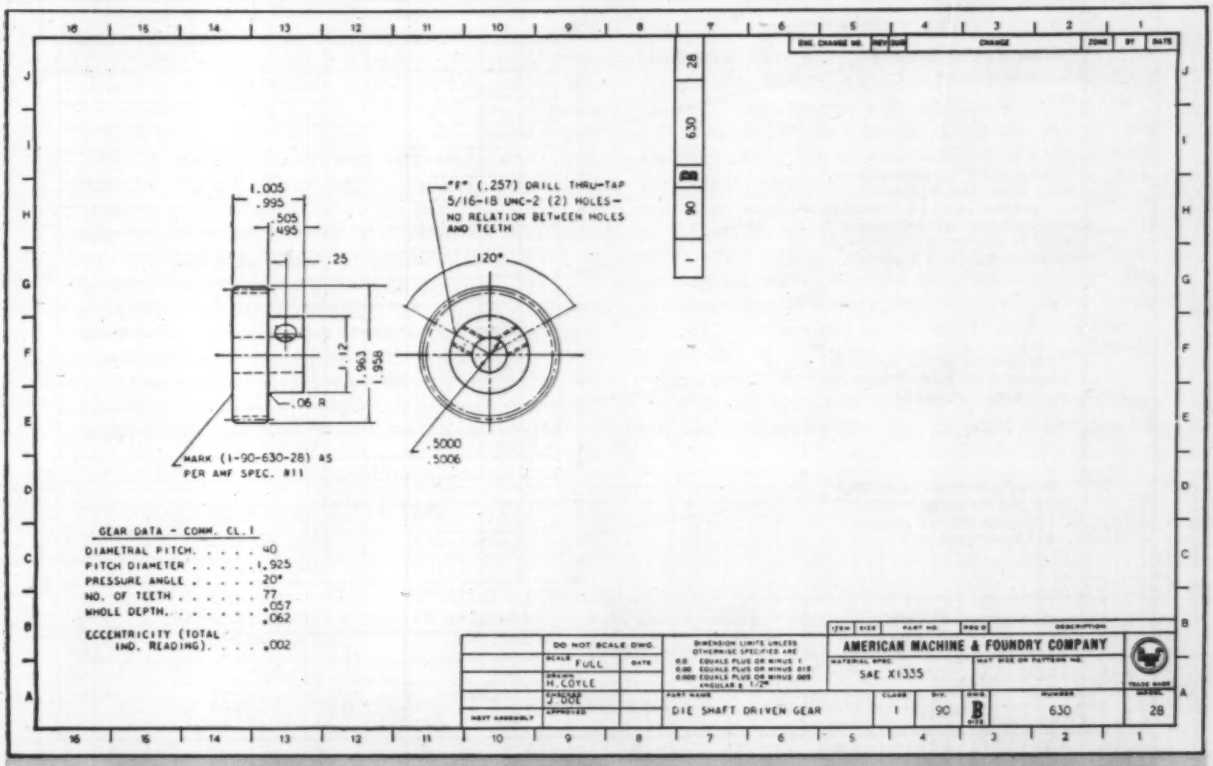


Fig. 2—Above—Engineering drawing showing identification of part as to class, division, part and model numbers.

Fig. 3—Below—Listing drawing of various models available of part shown in Fig. 2.

MOD. NO.	CIG. LENGTH IN M/M	NO. OF TEETH	BASIC P.D.	DETAIL DATE
10	59	59	1.475	5/22/51
11	60	60	1.500	10/20/48
12	61	61		
13	62	62	1.550	11/14/47
14	63	63	1.575	11/14/47
15	64	64	1.600	7/11/47
16	65	65	1.625	8/26/46
17	66	66	1.650	9/2/47
18	67	67	1.675	5/8/46
19	68	68	1.700	3/5/46
20	69	69	1.725	8/26/46
21	70	70	1.750	11/30/36
22	71	71	1.775	9/2/47
23	72	72	1.800	3/4/46
24	73	73	1.825	9/2/47
25	74	74	1.850	9/23/46
26	75	75	1.875	8/26/46
27	76	76	1.900	11/14/47
28	77	77	1.925	8/14/47
29	78	78	1.950	11/14/47
30	79	79	1.975	11/14/47
31	80	80	2.000	6/11/46
32	81	81	2.025	11/14/47
33	82	82	2.050	11/14/47
34	83	83	2.075	11/15/47
35	84	84	2.100	11/15/47
36	85	85	2.125	2/19/41
37				
38				
39				
40				
41				
42				

FORMULA - THE NUMBER OF TEETH IN GEAR IS ALWAYS EQUAL TO THE NUMBER OF M/M IN THE LENGTH OF CIGARETTE.

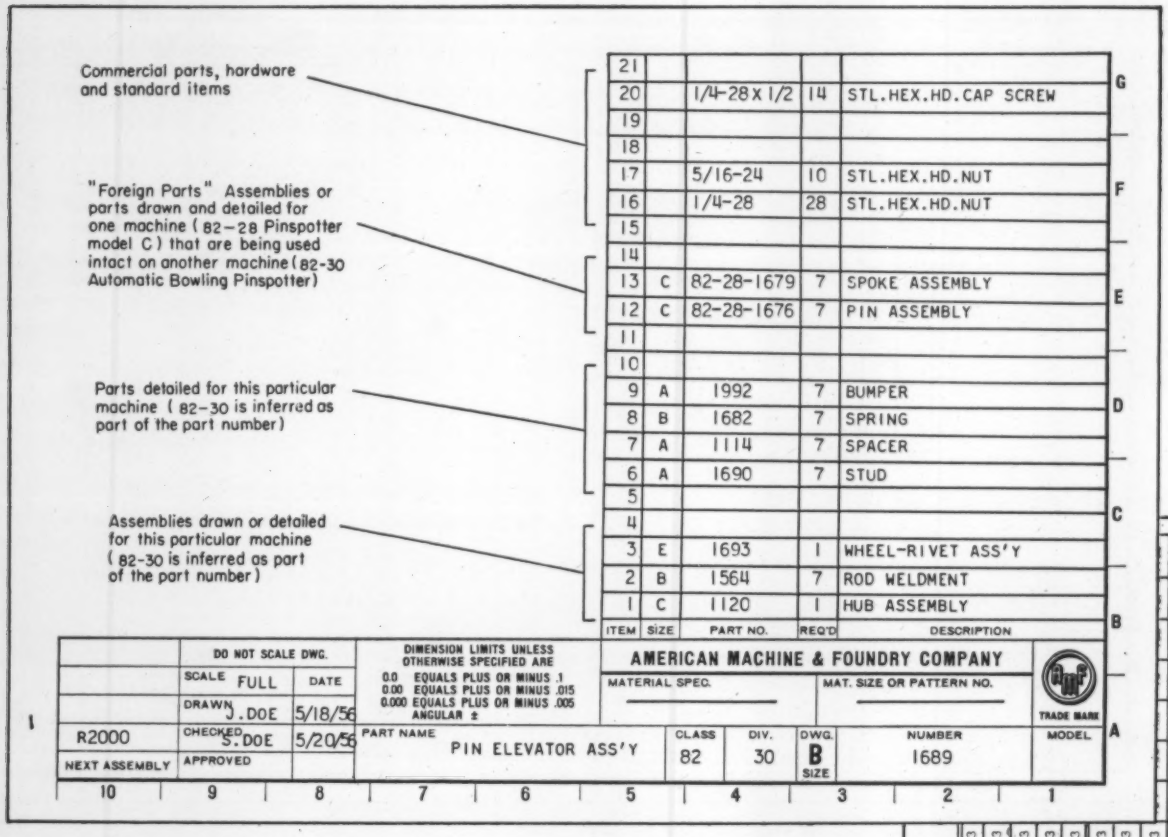
NOTE: P.D. IS UNDERCUT .C12 .C14 UNDERSIZE SO THAT THE GEARS WILL NOT PREVENT THE DIE FROM MAKING CONTACT WITH THE IMPRESSION DRUM.

LIMITATIONS - THE GEAR MAY NOT HAVE LESS THAN 59 TEETH BECAUSE OF INTERFERENCE BETWEEN 1-90-629 & 1-90-630 & NOT MORE THAN 110 TEETH BECAUSE OF INTERFERENCE WITH GEAR 1-90-624.

REASON FOR MODELING

CHANGE OF CIGARETTE LENGTH

DO NOT SCALE DWG. SCALE DATE
DRAWN H. COYLE 1/8/51
CHECKED
APPROVED
NEXT ASSEMBLY
AMERICAN MACHINE & FOUNDRY COMPANY
MATERIAL SPEC. SAE X1335
PART NAME DIE SHAFT DRIVEN GEAR
CLASS 1
DIV. 90
DWG. SIZE B
NUMBER 630
MODEL 10 TO 42 INCL.


Commercial parts, hardware and standard items
"Foreign Parts" Assemblies or parts drawn and detailed for one machine (82-28 Pinspotter model C) that are being used intact on another machine (82-30 Automatic Bowling Pinspotter)
Parts detailed for this particular machine (82-30 is inferred as part of the part number)
Assemblies drawn or detailed for this particular machine (82-30 is inferred as part of the part number)
21
20 1/4-28 X 1/2 14 STL.HEX.HD.CAP SCREW
19
18
17 5/16-24 10 STL.HEX.HD.NUT
16 1/4-28 28 STL.HEX.HD.NUT
15
14
13 C 82-28-1679 7 SPOKE ASSEMBLY
12 C 82-28-1676 7 PIN ASSEMBLY
11
10
9 A 1992 7 BUMPER
8 B 1682 7 SPRING
7 A 1114 7 SPACER
6 A 1690 7 STUD
5
4
3 E 1693 1 WHEEL-RIVET ASS'Y
2 B 1564 7 ROD WELDMENT
1 C 1120 1 HUB ASSEMBLY
ITEM SIZE PART NO. REQ'D DESCRIPTION
G F E D C B A
DO NOT SCALE DWG.
SCALE FULL DATE
DRAWN J.DOE 5/18/56
CHECKED S.DOE 5/20/56
APPROVED
DIMENSION LIMITS UNLESS OTHERWISE SPECIFIED ARE
0.0 EQUALS PLUS OR MINUS .1
0.00 EQUALS PLUS OR MINUS .015
0.000 EQUALS PLUS OR MINUS .005
ANGULAR ±
AMERICAN MACHINE & FOUNDRY COMPANY
MATERIAL SPEC.
MAT. SIZE OR PATTERN NO.
TRADE MARK
R2000
NEXT ASSEMBLY
PART NAME PIN ELEVATOR ASS'Y
CLASS 82
DIV. 30
DWG. SIZE B
NUMBER 1689
MODEL
10 9 8 7 6 5 4 3 2 1

part originally specified as S.C.M. 100 became 1-1-100.

Fig. 1*a* is a breakdown and description of the type of numbering system used at AMF.

Part Number: The part numbers are identical with the drawing numbers of the parts, subassemblies or assemblies which they represent, and are assigned sequentially. The part numbers are nonsignificant and, as such, the digits serve no purpose other than the proper identification of a part of a machine which has a specified class and division number. The proper delineation of a specific part should include the class and division number as well as the part number since the same part number may be repeated in each class and/or division, although no similarity exists between the parts themselves.

For example, part numbers 82-10-1358, 1-89-1358 and 82-11-1358 have no relation to each other at all. They might be a spring, gear and a casting, respectively, even though they all have the same part number. According to the class and division numbers, however, the spring is a part of the Bowling Equipment Ball Thrower (82-10), the gear is a part of the Standard Cigarette Machine Tobacco Feed (1-89) and the casting is a part of the Bowling Equipment Pin Storage Device (82-11). This system allows identification of a great variety of parts using a minimum of part numbers, thus limiting all part numbers to four digits.

Fig. 4 — Above—Assembly drawing parts list. Parts originally made for other machines are identifiable as "foreign parts," carrying complete class, division and part numbers.

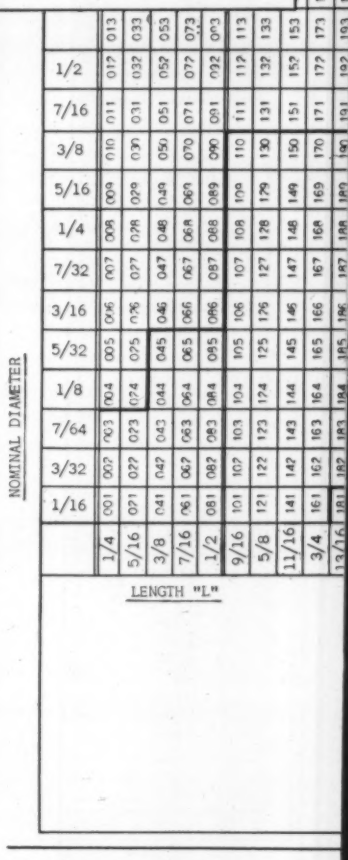


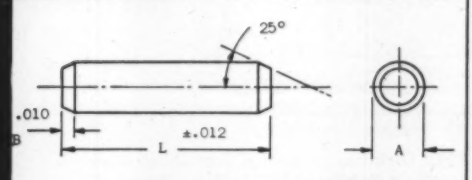
Fig. 5 — Suggested form for standard parts drawings. Diameter and length of part serve as co-ordinates to indicate part number. Preferred sizes are within the heavy black lines. List of model part numbers is used here to specify finishes.

Interchangeable Parts: Various models are available of many machines manufactured by AMF. The parts of these basic machines that vary from model to model, but are still interchangeable, are known as model parts. By definition, model parts belong to a family of interchangeable parts which perform the same function in each model of a given machine, but which differ only to accommodate changes in the dimensions of the end product, alternate machine mechanisms or accessories, or dimensional changes of the product being processed or handled by the machine.

In the original descriptive system, model parts were identified by shape number, etc., as in S.C.M. 125-Round 26M/M. When converted to the numerical system, the model part numbers became the additional group of digits following the part number and indicated the functional differences of otherwise interchangeable parts. Thus S.C.M. 125-Round 26M/M becomes 1-1-125-10. The delineation of model part numbers is illustrated in Fig. 1b.

An excellent example of a model part is the die for cutting the tobacco leaf for the outer wrap of a cigar. Although all cigars appear to be physically the same, actually there are many variations in the outer wrap. Hundreds of interchangeable outer wrap dies are available for a standard cigar making machine. When a machine is ordered, the customer must specify the type of outer wrap desired on the cigar to be made, and the appropriate die is delivered with the machine. When using the numerical model part numbering system, the original part will not carry a model number, but the first model part will be given a designation

MOD.	DESCRIPTION
11	FINISH #29
12	FINISH #32
13	FINISH #40



DESCRIPTION	CLASS	DIV.
DOWEL PINS	95	1325

	Nominal Sizes	1/16	3/32	7/64	1/8	5/32	3/16	7/32	1/4
A	Diameter, Max.	.0600	.0912	.1068	.1223	.1535	.1847	.2159	.2470
	Diameter, Min.	.0595	.0907	.1063	.1218	.1530	.1842	.2154	.2465
B	Chamfer Length	.015	.015	.015	.015	.015	.015	.015	.015

	Nominal Sizes	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1
A	Diameter, Max.	.3094	.3717	.4341	.4964	.6211	.7458	.8705	.9952
	Diameter, Min.	.3089	.3712	.4336	.4959	.6206	.7453	.8700	.9947
B	Chamfer Length	.030	.030	.030	.030	.045	.045	.060	.060

of 10; the second, 11; the third, 12; and so on, as shown in Figs. 2 and 3.

Fig. 2 is a detail drawing of a model part to be used by the machinist in the manufacture of this part. Fig. 3 is a model part listing drawing itemizing the various models of this particular part and briefly noting the basic differences in each part. The listing drawing is for reference only and is not to be used in fabrication of the part.

Each detail or assembly drawing sheet shows the class and division number as an integral part of the drawing number. However, in cases where it will not lead to confusion, the class and division number is often omitted on drawings and parts lists as a convenience or time saver. On an assembly drawing, the bill of materials which identifies the various parts and subassemblies which make up the assembly includes the class and division numbers only in connection with "foreign parts." Thus any parts called out on an assembly drawing are of the same class and division as the assembly itself, unless otherwise noted.

Foreign Parts: This numbering system facilitates identification of parts made for a machine of one class and used on a machine of an entirely different class. When this is done, the parts being used from the different machine are considered "foreign parts," and the drawing numbers are listed as such on the assembly drawing parts list, Fig. 4. In this example, the foreign parts are of the same class as the assembly on which they are being used; however, the division numbers are different. In other cases, the class number and/or the division number may differ from that of the assembly on which the part is included.

The parts list, or bill of material, is handled in approximately the same manner as an assembly drawing. Each page contains the class and division number of the applicable machine, and all parts called out on that page show only the four-digit part number. All foreign parts are listed on a separate page or pages of the parts list. Each foreign part is labeled with the appropriate class and division number.

Standard Parts Numbers: At present, AMF is engaged in the development of a Master Standard Parts Catalog. Although this program is in the embryonic stage, it is evident that the existing numbering system can be applied.

Classes 95 and 96 were assigned to Standard Parts (Mechanical) and Standard Parts (Electrical), respectively. For standard parts, four digits have been assigned for division numbers and three digits for part numbers. By this means, 9999 division numbers are available for different types of standard parts, since each part will carry a different division number. Within a given division, the three-digit part numbers allow identification of 999 different sizes of variations of a given standard part. The additional three-digit model number will cover 999 variations in finishes, materials, or combinations of both.

The format shown in Fig. 5 approximates the eventual form for standard parts drawings. This form has not yet been finalized; however, it is expected that each standard part drawing will include general information such as material, application and finishes. Critical dimensions will also be listed, and preferred sizes will be indicated by the heavy lines. An example of a typical standard part is: Part Number 95-1325-124-12 Dowel Pin.

Further examination of Fig. 5 indicates that the part involved is a dowel pin, $\frac{1}{8}$-in. in diameter by $\frac{5}{8}$ in. long. Model number 12 represents finish No. 32 zinc plating, which shall be in accordance with the specification for zinc plating set forth in the AMF *Standard Book*.

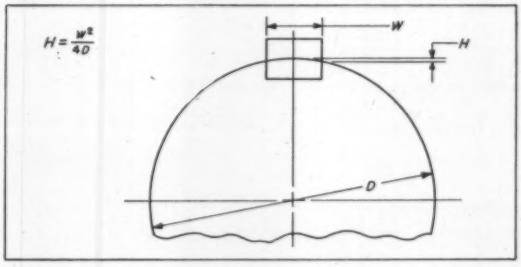
Adequacy of the System: The numerical class and division system has proved flexible enough to be used for all parts manufactured to date and appears adequate to cover those resulting from future expansion. During the first 50 years of the company's development only 99 class numbers were used.

The numbering system to be employed on engineering drawings is a matter for serious consideration. Any company, after carefully examining its product output in the light of past experience and future possibilities for technical and physical development, can formulate a numbering system that will stand the test of time. This is the only true measure of the success of any system.

Tips and Techniques

Determining Keyway Depth

The depth of a square keyway, H, in a round shaft may be determined by a simple formula,



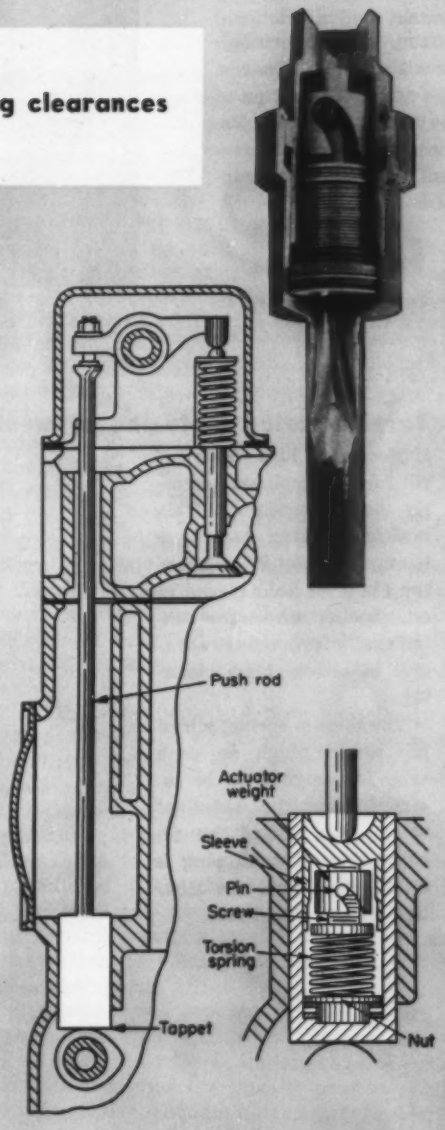
$H = W^2/(4D)$. This formula is useful for determining the dimensions of the keyway in both the shaft and the mating part. The height of any geometrical sector may be found with the formula. —JOSEPH MORVAK, *Minneapolis*.

scanning the field for *ideas*

Automatic adjustment of operating clearances in cam-driven linkages is accomplished by a novel all-mechanical compensating system. A combination valve lifter and automatic valve adjuster has been developed by Allied Precision Products to compensate for dimensional variations in engine valve-train components caused by temperature changes, wear, etc.

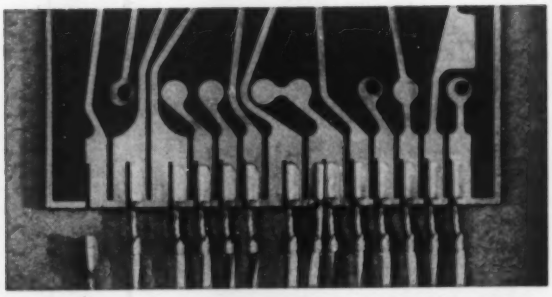
The valve adjusting mechanism consists of a torsion spring, a screw-and-nut assembly, a sleeve member, and an actuator weight. The torsion spring, which has one end fastened to the nut and the other into the screw shaft, automatically rotates the nut with respect to screw until the attached sleeve member bears tightly against the push rod. Under these conditions there is no slack in the valve train and tappet noise is eliminated.

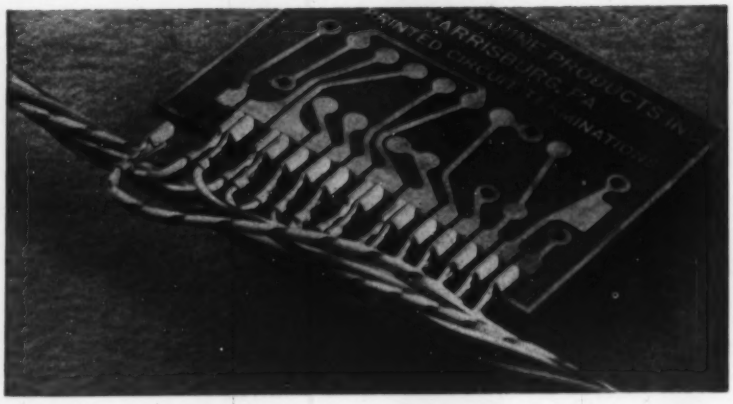
During engine operation, when the valve lifter decelerates as it leaves the cam ramp (valve is being seated) and moves onto the cam base circle, the slotted actuating weight strikes against a pin in the screw element. This action rotates the screw in a direction that shortens valve-lifter length 0.0001-in., assuring positive seating of the valve. During the dwell period the torsion spring again removes all slack in the valve train.



Slide-on electrical connector

designed in the form of a U-shaped plug and slotted receptacle assures positive contact and offers cost advantages in printed-circuit construction. Developed by Amp Inc., the design provides both a wiping contact and a frictional locking grip to printed-circuit terminal boards. The open construction of the U-shaped design assures aeration to prevent moisture entrapment.

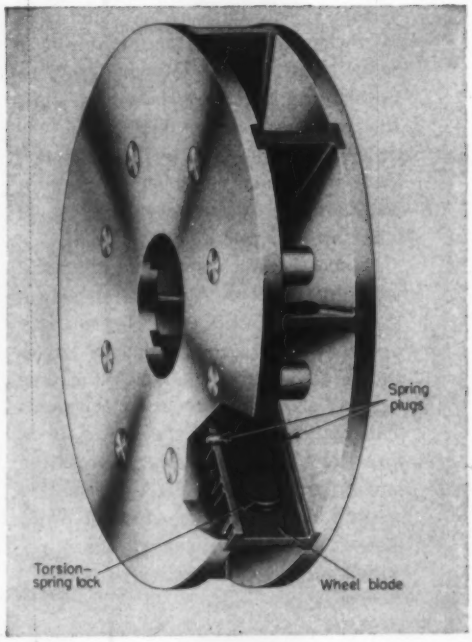


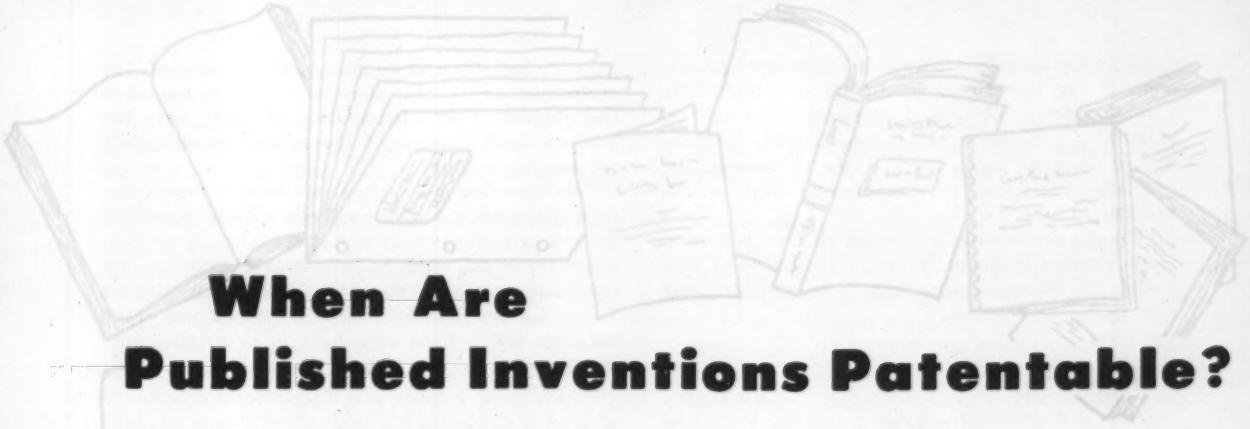


Torsion-spring fastening of mechanical elements

subjected to high centrifugal forces simplifies assembly and disassembly. This positive locking technique is employed by Wheelabrator Corp. to hold blades in an impeller wheel for centrifugally propelling abrasive in airless blast cleaning.

The torsion spring, which has small plugs on each arm, is designed to be inserted into the sides of wheel. One half of the circular area of each plug is in the blade and the other half in the wheel side.





When Are Published Inventions Patentable?

By Albert Woodruff Gray
Forest Hills, New York

Although it has been established beyond question that a published description of an invention is fatal to a patent application made later, the words *printed publication* in the patent statute have frequently been restricted in their interpretation by the courts. This article, by means of actual court cases and subsequent rulings, shows when catalogs, booklets, leaflets, research reports, college theses and foreign publications are considered prior printed publications for purposes of determining patent validity.

THE present patent statute contains the provision, "A person shall be entitled to a patent unless—(a) The invention was known or used by others in this country or patented or described in a printed publication in this or a foreign country before the invention thereof by the applicant for patent, or (b) The invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country more than one year prior to the date of the application for patent in the United States."

■ Catalogs

Application was made for a patent of an electric lighting-fixture design patterned after a lighted candle. Published 4 years before in the catalog of a German manufacturer was the price list of various light sockets, with illustrations. One of these described as a candle socket with a porcelain base was similar in every way to the disclosure in the patent application. More than 1000 of these catalogs had been mailed to customers in the sale of this merchandise during the year.

When suit was later brought for the infringement of the patent issued on this application, the defense was set up that the patent was invalid since the publication of the description of the invention in these catalogs, under the provision of the statute, had forfeited the right of the inventor to the patent.

Such a defense had been interposed a few years before in an action brought for the infringement of the design patent of a glass bowl. Printed catalogs circulated in the glass trade had been produced by the defense that disclosed this same design.

"Certainly manufacturers' catalogs so circulated are more effective in spreading information among persons skilled in that art than if the same catalogs were only on file in some public library," said the court referring to a decision many years before, and since then severely criticized, that the publication of an invention, not found in a library, is in itself not a violation of the patent law provision.

"That these catalogs had been sufficiently circulated to bring them to the notice and possession of an alleged infringer is enough to indicate due publication."

In its decision of the infringement suit based on the electric-light patent the lower court held that catalogs failed to show sufficiently a violation of the prohibition of the statute against publication. That decision was appealed and in its reversal by the Federal appellate court it was said of catalog publication, in holding this design patent forfeited on that ground,

"On principle we are entirely in accord, for the purpose of the statute is apparent and we ought to effect it so far as its language will allow. While it is true that the phrase 'printed publication' presupposes enough currency to make the work part of the possessions of the art, it demands no more.

"A single copy in a library, though more permanent, is far less fitted to inform the craft than a catalog freely circulated, however ephemeral its existence, for the catalog goes direct to those whose interests make them likely to observe and remember whatever it may contain that is new and useful.

"No one can seriously suppose that such a document, printed in quantity, was intended to be kept secret. Its whole purpose was to be spread broadcast as far as possible."

■ Booklets

Only a few years ago in a suit in a Federal court in New York State for a declaration of the validity of a patent for fireproof construction issued to a Karl Schuster, the defense was based on a booklet of which between 50 and 100 copies had been printed. This the patentee contended was not a publication of the patent within the meaning of the patent statute provision but a scheme for fireproof construction.

Of this defense that court said, "This on the face of it seems absurd. The booklet itself on the cover is entitled, 'Schuster Systems.' The matter is not set off in any way or differentiated from the other printed matter. One can only conclude that it is part of the 'Schuster System' put out to the trade for exploitation. The opening paragraph of the booklet indicates this: 'In presenting this introductory catalog for the consideration of Architects, Engineers, Contractors and others interested in the erection of fireproof buildings we call attention to many advantages which led to the adoption of Schuster Systems . . .'"

In its conclusion that this booklet was a printed publication within the meaning of the statute and grounds for a declaration of the invalidity of the patent, the court added, "This booklet was used for promotion purposes for more than two years prior to the date of the application for a patent."

■ Leaflets

Interpretation of the satute as prohibiting under the term printed-publication descriptions of inventions in trade catalogs received even greater emphasis in the suit by the patentees of a sanitary device for infringement. Here it appeared that more than 5000 leaflets had been sent to hospitals throughout the country, "To see if it was a practical idea, if it conformed to things that needed to be conformed to that would be considered good medical practice."

In holding that the broadcasting of advertising literature of this sort was unquestionably a violation of this provision of the law, the court here said,

"Each half dozen of said devices together with one of these printed leaflets was contained in a separate box. That accounts for the broadcasting of nearly two thousands of the leaflets. None of the recipients were enjoined to secrecy but all of the recipients were free to use them as they pleased and they were not used by any of the recipients under the directions of the patentee, the purpose of the distribution being to have the leaflets teach the use of the applicator as widely as possible.

"No case has been cited nor have I found any in which such a leaflet has been held to be or not to be a printed publication but considering the purposes for which such leaflets were distributed and the large number of them that were so distributed I can see no difference between them and trade catalogs which have been held to be printed publications."

■ Research Reports

In a suit for the infringement of patents for chromium plating, the defense contended that the process had been disclosed in research reports of a chemist employed by laboratories in the chemical industry. None of these reports had been made public although a number of copies had been distributed among the officers of chemical companies. The information, however, had been held in confidence and the information kept entirely within the organizations.

Ruling here that such reports were not publications within the meaning of the statute, the Federal court said, "They [research reports] were not publications. Like an application for a patent they were confidential writings which were kept secret and inaccessible to the public."

Then, quoting from an earlier decision, "Whether the conception slumbers buried in the ashes of the past, lies inchoate in the brain of the would be inventor or is locked in the breast of its creator, it cannot afterwards be dug up, developed or set free to question the title of the complete creation first brought forth into the world of knowledge and thus, as the first born, the rightful heir to the parent estate. As against an original inventor anticipation is not shown by prior use of the invention under conditions which fail to disclose its composition or operation. Such knowledge of the invention should be accessible to the public.

"If the alleged prior use of the process was under such circumstances that the public obtained no knowledge of the mode of its operation, or of the results to be obtained by it, there is no prior use within the meaning of the patent law. If kept secret by the first inventor until the second has discovered it and given it to the public, the latter will be protected for it is to him that the public is indebted, it is from him that the public has received value."

In another instance before the Federal court the following year, the infringer maintained that the process for increasing the recovery of oil from wells of limestone formation had been published prior to the granting of the patent. Assistants of the Mellon Institute had been enlisted by an oil producer to determine the cause of gypsum deposits on pumping equipment and a method for both its prevention and removal. This report had been submitted, and its suggestions determined to

be scientifically successful and economically unsuccessful.

In its ruling that here there had been neither publication nor disclosure within the meaning of the statute that court said, "While the patentee is charged with knowledge of the prior art in determining the question of inventive genius, including disclosures of part of his conception in one patent and part in another, it is not true that when invalidity exists notwithstanding the background, such invalidity is negatived and an otherwise valid patent anticipated by various steps selected from several other patents, nor from a use which was not designed for, adapted to, or actually used to produce the result accomplished by the patent assailed."

College Theses

Research work on germicides had been the subject of a thesis of a student at Iowa State College. Subsequently this thesis was deposited in the college library and available to other students and libraries. When later a patent had been issued on the process outlined in this thesis and suit brought in protest against the infringement, the thesis, it was contended, had been a publication invalidating the patent. While in the lower court it had been held that the thesis by being placed in the college library, was not published, the Federal appellate court said,

"It was put on file in the library of the college, available to students there and to other libraries having exchange arrangements with Iowa State. We think that intent that the fruits of research be available to the public is determinative of publication under the statute whether the paper be printed or typewritten."

Foreign Publications

Often this defense of printed publication is based on foreign publications in other countries. When an application for a testing machine patent was denied by the Commissioner of Patents a few years ago on the ground that it had been described in a printed publication, an appeal was taken by the applicant to the Federal appellate court.

This circular had furnished at best but a superficial picture of the machine and its various features. In ordering the granting of this patent application and overruling the decision of the Commissioner the court said,

"A defense of invalidity of the patent in suit because described in a foreign publication is not made out unless it is shown that the descriptions and drawings of the foreign publication contain and exhibit a substantial representation of the patented improvement in such full, clear and exact terms as to enable a person skilled in the art or science to which it appertains, to make, construct and practice the invention to the same practical extent as they would be enabled to do if the information was derived from a prior source.

"Here vague and general representations will not support such a defense as the knowledge supposed to be derived from the publication must be sufficient to enable those skilled in the art to understand the nature of the invention and to carry it into operation.

"It is not competent to read into a foreign publication any information which it does not afford on its face. The disclosure of a foreign publication must be so clear that it teaches the subject matter of the patent in suit without assistance from the latter.

"A document so obscure in its terminology that two conflicting theories may be deduced therefrom and supported by equally plausible arguments is too indefinite to be utilized as an anticipation. These principles although applied by the courts and referred to infringement suits, are equally applicable to proceedings to obtain a patent. That is to say, a foreign publication cannot operate to anticipate a claimed invention unless it satisfies these principles."

This frequent stumbling block to the granting of patents and to the sustaining of the validity of those already granted, was summarized many years ago by the United States Supreme Court. That decision still stands as unquestioned authority in the application of these provisions to any prior printed publications.

"Patented inventions cannot be superseded by the mere introduction of a foreign publication of the account, though of prior date, unless the description and drawings exhibit a substantial representation of the patented improvements in such full, clear and exact terms as to enable any person skilled in the art or science to which it appertains, to make, construct and practice the invention to the same practical extent as they would be enabled to do if the information was derived from a prior patent.

"Mere vague and general representations will not support such a defense as the knowledge supposed to be derived from the publication must be sufficient to enable those skilled in the art or science to understand the nature and operation of the invention and to carry it into practical use. Whatever may be the particular circumstances under which the publication takes place, the account published, to be of any effect to support such a defense, must be an account of a complete and operative invention capable of being put into practical operation."

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Linearity problems in

COMPRESSION SPRINGS

. . . their causes and cures

NONLINEARITY of the load-deflection relationship of compression springs frequently presents a problem, especially in the design of springs for precision instruments.

In the central portion of the operating range of most helical compression springs, the spring gradient—load required to deflect a spring a given distance—is generally considered constant for all practical purposes, although it is never absolutely so. However, at both extremes of the full operating range, the load-deflection relationship of a compression spring deviates from linearity substantially. This is because no spring can be made so that all its coils will become inoperative simultaneously, and also because no spring can be squared and ground so perfectly that it will be exactly square with its axis.

Load Characteristics: A plot of load versus deflection for a typical helical compression spring is shown in Fig. 1. As it is increasingly loaded, the spring is compressed from its "free-length" H to solid height h.

From the curve it can be seen that the gradient, K, is relatively flat and increasing as the spring is initially compressed from its free-length. Seating and adjusting of the spring to become square with its axis causes this effect. The condition is greatly exaggerated in Fig. 1, and usually disappears after a very short deflection. The effect can be avoided in practice by not designing springs for use within 10 per cent of their free length.

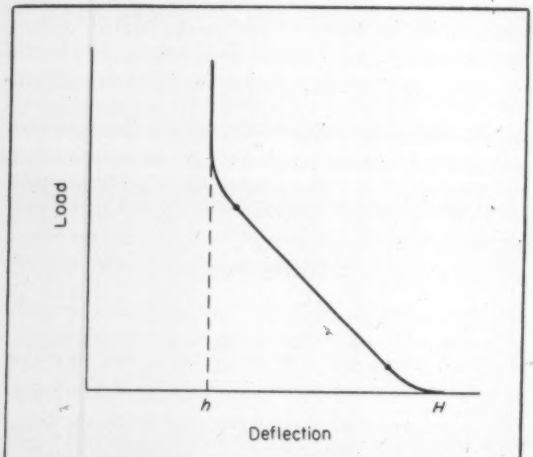

Fig. 1—Typical load-deflection characteristics of helical compression springs.

As it is compressed farther, the seated spring tends to exhibit a relatively constant gradient. Actually the gradient always increases slightly because, during continued compression, the number of active coils decreases. The increase in mean diameter which also occurs never fully counteracts the effect of the constant decrease in the number of active coils.

As the compression spring is deflected, it reaches a point, just before being compressed to solid height, where a rapid rate of increase of the gradient takes place and the load-deflection characteristic loses any semblance of linearity. This occurs as certain coils begin to close out and become inactive before the others, thereby reducing the number of active coils. This condition is especially evident in squared-end springs because the pitch of the coils near the end has been gradually reduced to obtain a level end. Thus these coils must become inactive before the other coils. Five methods for preventing this occurrence are suggested.

Rectangular Wire: One solution is to use helical springs made from wire of rectangular cross section, Fig. 2*a*. Ends of the spring are ground to obtain the greatest possible bearing surface. Bearing surface should be at least $\frac{5}{8}$ (or 225 degrees) of the circumference of the end coil. To cut straight through the end coil at right angles to the spring axis to provide an end with this minimum bearing surface, the wire dimension, b, parallel to the spring axis should be at least $\frac{5}{8}$ of the spring pitch.

Coiled Spacer: If the relationship between the rectangular wire dimensions and the pitch is such that the ends cannot be squared to give enough bearing surface, a coiled spacer may be used, Fig. 2*b*. Also of rectangular section, the spacer, brazed as indicated, provides solid end bearing and a sharp transition from active to inactive coils at its end. After brazing, usually with silver alloy, the ends of the spacer are ground square to give a 360-degree bearing surface. This method can be employed best with springs made from heat-

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resistant alloys such as Type 302 stainless steel, Inconel, etc. Since the temperature required for brazing is detrimental to the properties of carbon steels, springs of music wire and hard-drawn spring steel are seldom spaced in this manner.

Spacer Between End and Active Coils: A frequently used though less satisfactory method of preventing too-early "closing-out" of end coils is to braze a spacer between the dead-end coil (or coils) and the first active coil at full pitch spacing, Fig. 2*c*. The spacer immobilizes all of the "transition coils."

Rivets, clips and other mechanical means may also be employed if the application of the spacer by heating is undesirable.

Special End Fitting: Specially machined end fittings, Fig. 2*d*, will accomplish the same purpose as the coiled spacer but are far more expensive to produce. They are sometimes justified by the design of the mechanism upon which the spring seats.

Helically Slotted Tubing: Construction of a spring by milling a helical slot from a section of tubing of a hardenable spring material, Fig. 2*e*, is another costly method of producing a very linear compression spring. Conceivably, its use could be justified in the design of an extremely fine instrument. After milling, the springs are mandrel hardened and tempered. Final test loads can be obtained by grinding the ends to the desired free length and centerless grinding the OD until the desired spring rate is obtained.

With no end coils to close out, the number of active coils remains the same in this spring throughout its deflection. Such a spring exhibits a high degree of linearity.

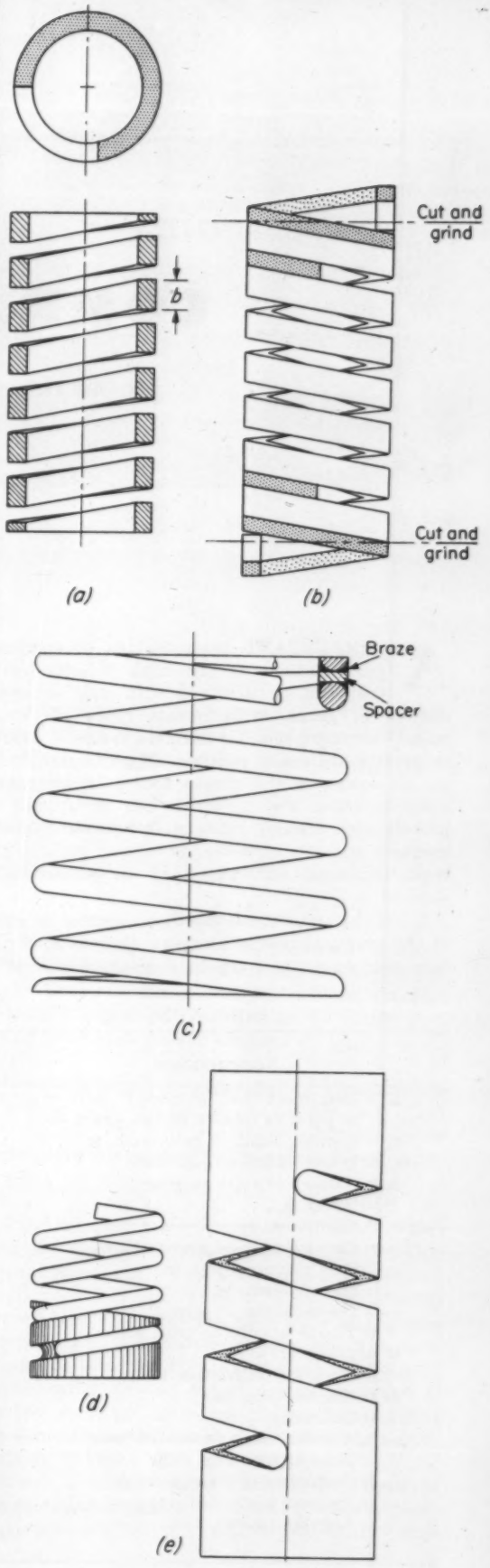


Fig. 2—Methods for preventing loss of linearity in helical compression springs. Design at *a* is made of rectangular wire with ends ground to provide maximum bearing surface. Similar rectangular wire construction at *b* has coiled spacers brazed to end coils for solid bearing. At *c* a spacer is brazed between dead end coils and first active coil to immobilize the end sections. Machined end fitting is used at *d* to provide maximum bearing surface. At *e* a compression spring with high linearity characteristics is obtained by milling a helical slot in a tubular section.

Designing

COMPOUND EPICYCLIC

for maximum efficiency at high velocity ratios

AN IMPORTANT basic feature of epicyclic gear systems is the high velocity ratio that can be achieved with only a small number of gears. With certain types of "compound" arrangements, for example, ratios of 2000:1 or greater are easily possible. Of particular interest in design is the simple four-gear compound epicyclic train, Fig. 1, which can be utilized to provide high velocity ratios with reasonably small numbers of teeth. However, as velocity ratio in the train increases, efficiency may be substantially reduced.

In this article, attention will be devoted to some of the practical possibilities and limitations of the four-gear epicyclic train in drive applications. A method is presented for selecting numbers of teeth of the different gears so that maximum efficiency is achieved at high velocity ratios.

Although developed for a specific system arrangement, design and analysis techniques presented here are generally applicable to all types of simple or compound epicyclic gear trains where efficiency is a critical factor.

Nomenclature

F = Gear tooth load, or normal force reaction at point of contact of two gears, lb
h_k = Working depth of gear teeth, in.
m_G = Velocity ratio of gear train
N = Number of teeth in gear
P = Power, hp
P_i, P_o = Input and output power, respectively, hp
p = Circular pitch of gear teeth, in.
r_b = Base radius of gear, in.
s = Displacement, in.
s_P = Displacement of point P, in.
T = Torque applied to gear, lb-in.
W = Work, in-lb
W_f = Work lost in friction, in.-lb
Δt = Elapsed time, sec
e = Efficiency
θ = Angular displacement of gear relative to plane of gear axis, radians
μ = Coefficient of friction
ϕ = Pressure angle, deg
ω = Angular velocity, rpm

Basic Concepts: In the compound four-gear train, Fig. 1, planet gears A and C rotate as a single unit on a spindle projecting from a planet carrier on input shaft E. Gear A meshes with fixed internal gear B, while gear C meshes with internal gear D mounted to output shaft F. If gear A is the same size as gear C and gear B is the same size as gear D, rotation of the input shaft will impart equal velocities to gears D and B, and the output shaft will remain at rest. However, if the ratio of the numbers of teeth in gears A and B is slightly different from that for gears C and D, the velocity of gear D will be nearly the same as that of gear B and the output shaft will be driven at much lower speed than the input shaft.
velocity of gear D will be nearly the same as that termined by established methods of analysis as:

$$m_G = \frac{\omega_E}{\omega_F} = \frac{N_A N_D}{N_A N_D - N_B N_C} \qquad (1)$$

where symbols are defined in Nomenclature and subscripts identify individual elements. However, the converse problem of selecting values of N_A, N_B, N_C and N_D so as to produce a specified velocity ratio, is not so straightforward.

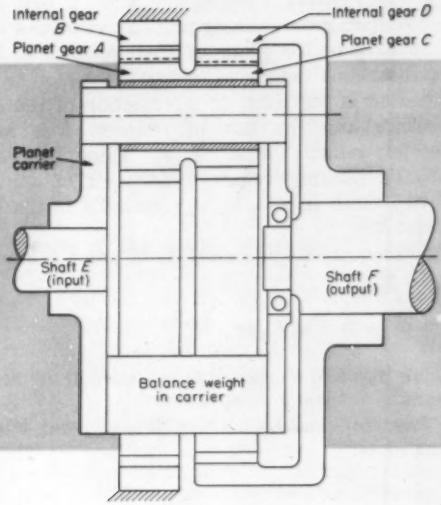
As a basis for approach, let

$$N_D = nN_A$$

$$N_B = nN_A + b$$

$$N_C = N_A - c$$

Fig. 1—Four-gear compound epicyclic train which can be used to obtain high velocity ratios.



GEAR TRAINS

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where n is any factor that makes product nN_A a whole number, and b and c are whole numbers. Then, from Equation 1,

$$m_G = \frac{nN_A^2}{nN_A^2 - (nN_A + b)(N_A - c)} = \frac{N_A^2}{N_A c + \frac{bc}{n} - \frac{N_A b}{n}} \qquad (2)$$

If $c = 1$ and $b = n$ (n must be a whole number greater than 1), then from Equation 2, $m_G = N_A^2$ or $N_A = \sqrt{(m_G)}$.

More generally, if $b = cn$ (the denominator of n expressed as a fraction must be a factor of N_A), from Equation 2, $m_G = N_A^2/c^2$ or $N_A = c\sqrt{(m_G)}$.

Suppose, for example, that a velocity ratio of $m_G = 10{,}000$ is desired in such a train. If $c = 1$, $n = 2$ and $b = 2$, $N_A = \sqrt{(10{,}000)} = 100$. Solving for the other gears of the train gives: $N_D = 200$, $N_B = 202$ and $N_C = 99$. From Equation 1, as a check on solution accuracy,

$$m_G = \frac{200(100)}{200(100) - 202(99)} = 10{,}000$$

Here, the internal gears are about twice as large in diameter as the planetary gears and there is no difficulty in using a standard tooth form.

The usual blank diameters, d, for these numbers of teeth would be, since addendum of a full-depth tooth is p/π,

$$d_A = \frac{(100 + 2)p}{\pi} = \frac{102\,p}{\pi}$$

$$d_B = \frac{(202 - 2)p}{\pi} = \frac{200\,p}{\pi}$$

$$d_C = \frac{(99 + 2)p}{\pi} = \frac{101\,p}{\pi}$$

$$d_D = \frac{(200 - 2)p}{\pi} = \frac{198\,p}{\pi}$$

Center distance l_{CD} for gears C and D, Fig. 1, with working depth equal to $2p/\pi$ would be

$$l_{CD} = \left(\frac{198 - 101}{2} + 2\right)\frac{p}{\pi} = \frac{50.5\,p}{\pi}$$

and for gears B and A,

$$l_{AB} = \left(\frac{200 - 102}{2} + 2\right)\frac{p}{\pi} = \frac{51.0\,p}{\pi}$$

To equalize these center distances, the blank diameter of gear A could be increased to $d_A = 103\,p/\pi$, making the common center distance $l_{AB} = l_{CD} = 50.5\,p/\pi$. Alternatively, the blank diameter of gear C might be decreased to $d_C = 100\,p/\pi$, giving a common center distance of $l_{CD} = l_{AB} = 51\,p/\pi$.

The teeth would be generated by standard cutters sunk into the blanks to slightly more than full standard depth to provide some backlash when these gears are meshed at the designed center distance.

Power loss by tooth friction in a pair of conventionally mounted spur gears is usually less than one per cent of the transmitted power. Corresponding loss in a pinion and internal gear combination is even less. Thus, it is not immediately obvious that the efficiency of a train of the type shown in Fig. 1 can be extremely low. The basic reason for this condition is that tooth load is high corresponding to the output torque delivered at the low speed of the output shaft, while meshing speed of the teeth is high due to the high speed of the input shaft.

Where a high velocity ratio is developed by simple trains of gears in series, the heavy tooth loads are confined to the low-speed gears, while the high-speed gears have small tooth loads.

Tooth Friction Losses: Consider a pair of involute spur gears having angular velocities ω_1 and ω_2 relative to the plane of their axes, Fig. 2. The instantaneous center of relative rotation is point M, which is the point of intersection of the line of pressure and the line of centers. The relative angular velocity is $\omega_1 + \omega_2$. Thus, the relative velocity (sliding velocity) at point of contact P of two teeth is $x(\omega_1 + \omega_2)$ where x is the length of line MP.

In time Δt, displacement s_P of point P along line $B_1 B_2$ is

$$s_P = \omega_1 r_{b1} \Delta t = \omega_2 r_{b2} \Delta t \qquad (3)$$

where r_{b1} and r_{b2} are the base radii of the two gears.

The work lost in friction, W_s, at point P during time Δt is:

$$W_s = \mu F x(\omega_1 + \omega_2)\Delta t \qquad (4)$$

where F is the normal force at point P. Now, let

$$Z = \frac{\text{Work lost in friction}}{\text{Work done on driven gear}} = \frac{W_s}{F s_P} \qquad (5)$$

Combining Equations 3, 4 and 5 gives:

$$Z = \frac{\mu x(\omega_1 + \omega_2)}{\omega_1 r_{b1}} \qquad (6)$$

Since $\omega_2/\omega_1 = r_{b1}/r_{b2}$, Equation 6 may be expressed as

$$Z = \mu x \left(\frac{1}{r_{b1}} + \frac{1}{r_{b2}} \right) \qquad (7)$$

Since Z is proportional to x, its mean value during the motion of point P through distance MA_1 is half the maximum value for that distance and the corresponding work lost in friction is, therefore,

$$W_s = \frac{\mu}{2} \left(\frac{1}{r_{b1}} + \frac{1}{r_{b2}} \right) F[MA_1]^2 \qquad (8)$$

Thus, for the motion of point P through distance A_2A_1, the total loss by friction, W_{sT}, is:

$$W_{sT} = \frac{\mu}{2} \left(\frac{1}{r_{b1}} + \frac{1}{r_{b2}} \right) F([MA_1]^2 + [MA_2]^2) \qquad (9)$$

Corresponding value of Z is $W_{\mu T}/(F[A_1A_2])$ or

$$Z = \frac{\mu}{2} \left(\frac{1}{r_{b1}} + \frac{1}{r_{b2}} \right) \frac{[MA_1]^2 + [MA_2]^2}{[A_1 A_2]} \qquad (10)$$

For a given distance A_1A_2, Z is a minimum when distance $MA_1 = [A_1A_2]/2$, corresponding approximately to the condition of equal addenda for the two gears. Many pairs of gears approximate this condition. At the same time, however, it is not uncommon for the addenda to have a ratio as high as 3:1 in which case (approximately), distance $MA_1 = 3[A_1A_2]/4$ and distance $MA_2 = [A_1A_2]/4$. Also, as a further approximation, distance $A_1A_2 = h_k/\sin\phi$.

Based on the foregoing conditions for a 3:1 addenda ratio, Equation 10 becomes:

$$Z = \frac{5\mu}{16} \left(\frac{1}{r_{b1}} + \frac{1}{r_{b2}} \right) \frac{h_k}{\sin\phi} \qquad (11)$$

By definition,

$$r_b = \frac{Np\cos\phi}{2\pi} \qquad (12)$$

From Equation 11 then, for conventional values of $\phi = 20$ deg, $h_k = 0.64p$ and $\mu = 0.05$, it can be shown that

$$Z = \frac{1}{5} \left(\frac{1}{N_1} + \frac{1}{N_2} \right) \qquad (13)$$

where N_1 and N_2 are the numbers of teeth in mat-

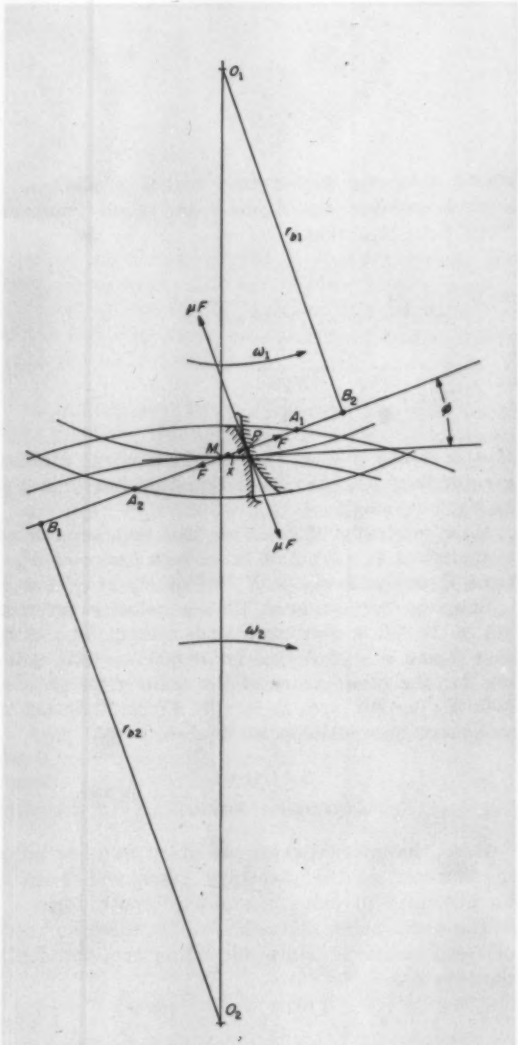

Fig. 2—Analysis of tooth action in mating gear pairs for determination of friction losses in compound epicyclic arrangements.

ing gears.

If one of the gears is an internal gear, the corresponding value of N becomes a negative number. This result indicates that where an internal gear with a large number of teeth meshes with a pinion nearly as big, tooth-friction loss is very small. Thus, it can be seen that a compound epicyclic gear train which is to be designed for a high velocity ratio with the highest practical efficiency must embody internal gears with large numbers of teeth, and large planets.

In the analysis of epicyclic gear trains it is necessary to give careful attention to the definition of Z, Equation 5. Displacement s_P is the displacement of the gear tooth along the line of pressure relative to the line of centers of the mating gears or, precisely, to the common plane of the axes of the gears.

Thus, displacement $s_P = r_b\theta$ while tooth load $F = T/r_b$. From Equation 5 then,

$$Z = \frac{W_s}{T\theta} \qquad (14)$$

where T represents the torque on either gear in the mating pair and θ is the angular displacement of the same gear relative to the common plane of the axes.

Consider now the pair of meshing gears, C and D, in Fig. 1. If the angular velocity of the output shaft is $\omega_F = 1$, angular velocity of the input shaft, and planetary spindle, is $\omega_E = m_G$ and angular velocity of gear D relative to the common plane of the axes of gears C and D is $\omega_D = m_G - 1$. Thus, the product of torque on gear D and its angular velocity relative to the axes of gears C and D is equal to the output power multiplied by the factor, $m_G = 1$. From Equations 13 and 14 then, the work lost in tooth friction between gears C and D is:

$$W_{s,CD} = \frac{1}{5}\left(\frac{1}{N_C} - \frac{1}{N_D}\right)(m_G - 1)W_F \qquad (15)$$

where $W_{s,CD}$ is the work lost in tooth friction and W_F is the output work delivered by shaft F.

If frictional loss in the spindle bearings of gears A and C is neglected, tooth loads at these gears will be nearly equal since their diameters are nearly equal. Thus, the loss in tooth friction between gears A and B is:

$$W_{s,AB} = \frac{1}{5}\left(\frac{1}{N_A} - \frac{1}{N_B}\right)(m_G - 1)W_F \qquad (16)$$

Total work lost in tooth friction is, from Equations 15 and 16,

$$W_{sT} = \frac{1}{5}\left(\frac{1}{N_A} + \frac{1}{N_C} - \frac{1}{N_B} - \frac{1}{N_D}\right)(m_G - 1)W_F \qquad (17)$$

and overall efficiency of the train becomes, therefore,

$$\varepsilon = \frac{1}{1 + \frac{1}{5}\left(\frac{1}{N_A} + \frac{1}{N_C} - \frac{1}{N_B} - \frac{1}{N_D}\right)(m_G - 1)} \qquad (18)$$

Design Example: To illustrate use of the equations, it will be assumed that a compound epicyclic train of the type shown in Fig. 1 is to be designed to provide a velocity ratio of 256:1. As in the previous discussion, factors c, n, and b will be assigned values of $c = 1$, $n = 2$ and $b = 2$. From Equation 2, $N_A = \sqrt{(256)} = 16$. Solving for the other gears of the train, based on the assigned factor values, gives: $N_D = 2(16) = 32$; $N_B = 2(16) + 2 = 34$; and $N_C = 16 - 1 = 15$. From Equation 1, as a check on these calculations, $m_G = 256$. Total tooth friction loss is, from Equation 17: $W_{\mu T} = 3.5\ W_E$ or, in terms of power, $P_{\mu T} = 3.5\ P_o$. Efficiency of the gear train, considering only tooth friction losses, would be, from Equation 18, $\varepsilon = 0.24$ or 24 per cent.

This efficiency value may not be acceptable, in which case it will be necessary to find a means of reducing the value of the quantity, $1/N_A + 1/N_C - 1/N_B - 1/N_D$. An easy way is to multiply the numbers of teeth already determined for the different gears by any whole number, say 3. Thus, $N_A = 48$, $N_B = 102$, $N_C = 45$ and $N_D = 96$. From Equation 17, tooth friction loss $P_{\mu T} = 1.17\ P_o$ and from Equation 18, $\varepsilon = 46$ per cent.

A further possibility is to make N_D and N_A more nearly equal by using a value of n between 1 and 2, say 1.25, with numbers of teeth in the range of 100. Under normal design circumstances, load capacity of the gears tends to be limited by tooth breakage if the numbers of teeth in pinions are much in excess of 80.

Using the relationship, $b = cn$, gives: $N_A = c\sqrt{(m_G)}$. The value of c to make N_A about 100 is then $c = 100/\sqrt{(256)} = 6.25$ or, for convenience, $c = 6$. Thus, $N_A = 6\sqrt{(256)} = 96$.

To make b as nearly equal to c as possible, let $n = 7/6$, which gives $b = 7$. Solving for the other gears then, based on the new factor values, provides: $N_D = 112$, $N_B = 119$ and $N_C = 90$. From Equation 1, $m_G = 256$. Tooth friction loss (Equation 17) becomes $P_{\mu T} = 0.214\ P_o$, and efficiency (Equation 18) is: $\varepsilon = 82$ per cent.

This value of efficiency may be regarded as satisfactory, although a higher value can be obtained by using still greater numbers of teeth and a somewhat lower ratio of N_D/N_A.

For a gear design of given material, diameter and width, increasing the number of teeth reduces the circular pitch. Thus, this approach is restrained by considerations of gear load capacity, as limited by tooth-breakage. Moreover, the numbers of teeth in a pinion and mating internal gear are limited by tooth interference problems to a certain minimum difference and a minimum ratio, depending on the ratios of the addenda of the mating teeth to their pitch.

High Velocity Ratios: The facility with which the four-gear compound epicyclic train can be designed to give very high velocity ratios is tempting. But, as demonstrated in the preceding example, it may give a low efficiency. For example,

a velocity ratio of about 2000:1 can be obtained by making $N_A = 45$, $N_B = 92$, $N_C = 44$ and $N_D = 90$. Operating efficiency of the train is only 10 per cent.

At the cost of an extra pair of gears to give an initial reduction of about 8:1, this ratio can be obtained (approximately) with an epicyclic train, such as the one in the example, having a velocity ratio of 256:1. The overall efficiency, neglecting losses other than those due to tooth friction would then be the product of about 0.97 for the extra reduction pair and 0.82 for the epicyclic gear train, giving a combined efficiency of about 79 per cent.

Importance of Efficiency: When the power transmitted is small, as may be the case in driving even a large machine if the speed is low, the cost of providing a larger motor and extra power to make up for the low efficiency of the gears may not be important. On the other hand, dissipation of the power lost in friction may be difficult. If natural cooling of the epicyclic gear unit by conduction, convection and radiation is relied upon, the temperature rise in the gear train may be too high for satisfactory lubrication by an oil that also is satisfactory for starting at low temperature. Artificial cooling by fan, cooling coil or circulation of oil to a separate cooling tank may then be necessary.

Problems in Mechanical Design: Based on the previous discussion, it can be seen that to minimize frictional losses in a compound epicyclic train, three important points must be kept in mind in design:

1. Use internal gears as fixed and driven members.
2. Make diameters of planet gears more than half as large as those of the internal gears.
3. Keep numbers of teeth in the 80 to 150 range.

Of these practices, item 3 tends to limit load capacity for given gear materials and diameters, while item 2 precludes the use of multiple planets, leading to a heavy resultant load on the driven internal gear which is overhung from the bearings of output shaft. Substantial mountings are therefore necessary for the bearings and for the planetary spindle since any deformation causes departure from uniformity of distribution of load across the width of the gears. Part of this difficulty is overcome by allowing the driven internal gear to act as the inner race of a large roller bearing in which the outer race is carried in the gear case.

For reasons of this kind, the compound epicyclic train tends to be expensive in relation to its load capacity as well as less compact than might at first seem possible.

Internal gears are not the easiest type of gears to manufacture and so the possibility of replacing them by external gears is naturally suggested. This substitution is kinematically possible but the change may mean a serious drop in efficiency since the basic relationship developed for internal gears, $1/N_A + N_C - 1/N_B - 1/N_D$, must then be replaced by $1/N_A + 1/N_C + 1/N_B + 1/N_D$. In the previous design example, this substitution would act to reduce the efficiency from 82 to 33 per cent.

Even if this reduction in efficiency can be tolerated, the four-gear train of external epicyclic gears has much lower load capacity within the same overall dimensions than the corresponding train with two internal gears. The inferior load capacity may, however, be offset by using multiple planetary pinions, but special arrangements are necessary in design, manufacture and assembly to assure a reasonably close approach to uniformity of load sharing between the planets.

Estimating Efficiency: The simplest method of estimating the efficiency of an epicyclic gear train is, first, to determine the angular velocity of every gear and carrier in the normal running condition. An output shaft torque is then assumed and the corresponding torque on each gear is calculated, assuming that the torques exerted on each other by a pair of meshing gears are proportional to the numbers of teeth.

The work lost by tooth friction between a pair of gears is equal to the product of a "loss factor," the torque on either gear and the angular displacement of that gear relative to the plane of the axes of the gears (Equation 14). The work input by a single shaft to an assembly of gears is equal to the work output plus the sum of the losses at the various mesh points.

By this method, it is not necessary to distinguish between positive or negative torques, between driving or driven gears, or between directions of so-called "flow of power."

If the total loss is found to be greater than the output work (that is, if the efficiency is less than 50 per cent), then the gears could not be rotated by a torque applied to what is normally the "output" shaft because otherwise the work lost in friction would exceed the input work. Such an assembly of gears in a train is said to be "irreversible."

"One of the interesting traits of our computers is the evidence of their universal tastes. They are devoid of prejudice; and never show resentment, as human computers so frequently do at being transferred from their field of special interest. We had reason to observe this recently when the computers were introduced to the nuclear field. The computation of the critical mass of reactors was made with the same dispatch as a routine harmonic analysis, and the problem of reactor flux distribution caused no more disturbance to the equanimity of the machine than the simplest stress problem. With such servants to aid us we shall have little excuse, indeed, if we fail to produce at least some of the miracles expected of us."—GEORGE J. HEUBNER JR., *Chrysler Corp.*

Release of latch 1 permits the spring to grip the input shaft and to accelerate the output. The output continues to rotate until latch 1, which is returned to its initial position by a spring, stops the spring retainer. The output shaft is decelerated by the other end of the spring and is permitted to override through a displacement which allows latch 2 to engage and hold the spring away from the input shaft so as to minimize frictional drag on the input.

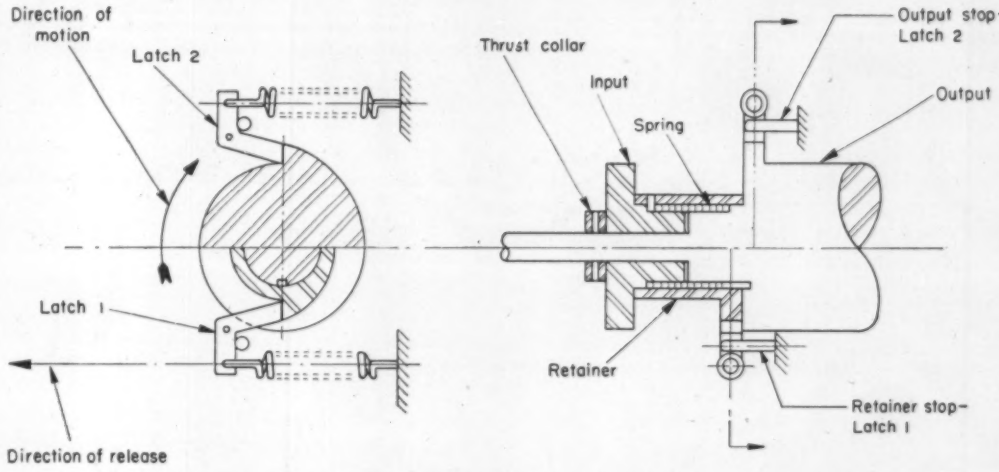

Fig. 1—Typical one-revolution spring clutch designed for sudden engagement at output with input shaft. Section shows both stops in locked position.

How to Calculate the Dynamic Load Capacity of

SPRING CLUTCHES

By Joseph Kaplan
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SPRING clutches are often used to transmit suddenly-applied dynamic loads. The characteristics which make them well suited for these applications are their high ratio of torque capacity to inertia and their shock-cushioning effects during the clutching operation.

Steady-state torque capacity for spring clutches has been formulated in a previous article.* However, the steady-state capacity is seldom the limiting design factor in dynamic applications. Clutch failures can be caused by overload phenomena brought about by transient loads. These conditions are considered in this analysis of spring clutches as commonly used for sudden coupling of a stationary shaft to a rotating shaft.

Clutching Action of a Rotating Shaft: The one-revolution clutch shown in Fig. 1 is typical of a machine element which effects sudden clutching of the rotating input member. It is used exten-

*J. Kaplan and D. Marshall—"Spring Clutches," MACHINE DESIGN, April 19, 1956, Pages 107-111.

sively in paper-feeding machinery and also in film-advance mechanisms. The input shaft is rotating continuously, while the output shaft is intermittently accelerated to full speed, rotated through one revolution and then stopped. The nature of the acceleration of the output depends on the transmission torque characteristics of the spring. In the steady state, the torque capacity is limited by one of two factors: insufficient grip, which leads to slippage, or excessive stress, which results in failure of the wire.

The gripping torque capacity is

$$T_g = M(e^{\mu\theta} - 1) \qquad (1)$$

Of the factors which affect T_g, M and θ can be held to close tolerances, but μ may vary appreciably with materials, finish, lubrication and other environmental factors. Moreover, μ appears in Equation 1 as an exponential factor which adds to the difficulty of holding T_g within narrow limits.

In certain applications, the only restriction placed on the clutch design is the ability to provide the required output torque with minimum over-riding friction. The number of turns, which is usually determined from space considerations, should in this case be as large as possible. From the angle of wrap thus established and the minimum coefficient of friction for the anticipated service conditions, the interference moment can be calculated with the aid of Equation 1.

For dynamic conditions, the interference moment must be increased to counteract the centrifugal effects and the subtractive action due to the acceleration of the spring and retainer. The centrifugal effect is

$$M_c = \frac{pD_d^3 A\omega^2}{4g} \qquad (2)$$

The moment caused by acceleration of the spring and retainer is

$$M_r = 2 I_r \alpha \qquad (3)$$

where α is the minimum desired angular acceleration of the clutch. The factor of 2 in Equation 3 accounts for the effective torque of the end coil for driving the retainer. The effective torque is half the maximum moment caused in the end coil. The total interference moment which is required to yield the minimum torque capacity of Equation 1 is

$$M_t = M + M_c + M_r \qquad (4)$$

In order to minimize the effect of Equation 3, it is good design practice to store a quantity of energy in the spring end sufficient to accelerate the retainer to full speed before the spring fully grips the input shaft.

The stress limiting torque capacity is

$$T_s = \frac{AD_d}{2}(S_w - S_b) \qquad (5)$$

The bending stress (S_b) is caused by the change in the radius of curvature of the spring coils from the free state to the assembled state. Torque is transmitted by the tensile force of the wire acting over the shaft radius $D_d/2$. To ensure long spring life, the sum of the bending and tensile stresses in the bridging coil should not exceed the working stress of the wire. The smaller value of torque as computed by Equations 1 and 5 represents the torque capacity of the spring. Generally, the parameters in Equation 5 are known quite accurately, and consequently the stress limiting torque capacity calculations are quite reliable.

The major part of the load is generally caused by the sudden acceleration of the stationary shaft. For a nonslipping spring grip, the stationary shaft is accelerated to full speed at a rate determined by the elongation of the spring wire. As long as the output shaft rotates at a speed lower than that of the input shaft, the wire continues to stretch. The maximum elongation of the wire,

Nomenclature

A = Cross sectional area of wire, sq in.
D_d = Diameter of drum, in.
e = Constant
E = Modulus of elasticity, psi
F = Pull of wire at bridging coil, lb
g = Acceleration of gravity = 386 in. per sec²
I = Moment of inertia, in-lb-sec²
k = Wire thickness, in.
l = Length of wire, in.
L = Elongation of wire, in.
L_s = Elongation of wire at maximum torque capacity, in.
M = Moment, lb-in.
M_c = Moment of centrifugal effect, lb-in.
M_t = Interference moment required to yield minimum torque capacity, lb-in.
N = Strain energy, in-lb
N_n = Net strain energy available for acceleration of output shaft, in-lb
N_s = Strain energy capacity of spring wire, in-lb
p = Density of wire, lb per cu in.
S_b = Bending stress of spring wire, psi
S_w = Working stress of spring wire, psi
t = Maximum acceleration time of output, sec
T = Transmission torque, lb-in.
T_g = Gripping torque capacity, lb-in.
T_s = Stress limiting torque capacity, lb-in.
α = Angular acceleration, radians per sec²
δ = Diametral interference of spring, in.
θ = Total angle of wrap of spring wire per drum, radians
μ = Coefficient of friction
ϕ = Effective angle of wrap of spring wire per drum, radians
ω = Angular speed, radians per sec

Subscripts: i denotes input shaft; o denotes output shaft; r denotes spring and spring retainer assembly; 1 identifies values calculated with maximum coefficient of friction; 1-1 identifies values, calculated with maximum μ, prior to output shaft motion; and 1-2 identifies values, calculated with maximum μ, during output shaft acceleration.

which coincides with the maximum stress, occurs when the input and output shafts achieve the same velocity for the first time during the acceleration period. The maximum elongation of the wire is evaluated, with the aid of the laws of conservation of momentum and energy:

$$I_i \omega_i + I_o \omega_o = I_i \omega_i' + I_o \omega_o' \quad (6)$$

and

$$\frac{I_i(\omega_i)^2}{2} + \frac{I_o(\omega_o)^2}{2} = \frac{I_i(\omega_i')^2}{2} + \frac{I_o(\omega_o')^2}{2} + N_s \quad (7)$$

From Equations 6 and 7, the strain energy at the instant when the output shaft, after being accelerated from rest, $\omega_o = 0$, attains the same speed as the input shaft, $\omega_i' = \omega_o'$, is

$$N_s = \frac{I_o}{2}\left(\frac{I_i}{I_i + I_o}\right)\omega_i^2 \quad (8)$$

In many designs it is required that the output of the one-revolution clutch have only a small fraction of the inertia of the input. For this case, Equation 8 can be simplified to the approximation,

$$N_s = \frac{I_o}{2}\omega_i^2 \quad (8a)$$

Equation 8 places a restriction on the spring clutch in that the strain-energy capacity of the spring wire represents a limiting factor for the maximum speed to which a given shaft can be accelerated.

Strain Energy and Elongation of Wire: Fig. 2 shows a typical curve of transmission force versus elongation of wire for a well-gripping spring-clutch. For a given applied torque which is smaller than the torque capacity of the clutch, only a fraction of the number of coils participate in the driving action. These coils are defined as the effective angle of wrap, ϕ. The effective angle of wrap for any torque can be calculated with the aid of Equation 1.

The elongation of the wire under load brings about relative motion between the input and output shafts. The expression is

$$\int dL = 2\int \frac{F dl}{AE}$$

where

$$F = \frac{2T}{D_d} = \frac{2M(e^{\mu\phi} - 1)}{D_d}$$

and

$$dl = \frac{D_d}{2} d\phi.$$

After integration of the above expression, the total elongation for a given angle of wrap is

$$L = \frac{2M}{AE}\left(\frac{e^{\mu\phi}}{\mu} - \phi - \frac{1}{\mu}\right) \quad (9)$$

Fig. 3, a plotting of the parenthetical term, simplifies the calculation of the wire elongation for a known effective angle of wrap for the coefficients of friction 0.1, 0.15 and 0.2.

The strain-energy input to the spring wire is the integral of transmission force and elongation, and is equal to the area under the curve in Fig. 2.

$$N_s = \int_0^L F dL$$

After the proper substitution and integration, the strain energy expression becomes

$$N_s = \frac{4M^2}{AED_d}\left(\frac{e^{2\mu\phi}}{2\mu} - \frac{2e^{\mu\phi}}{\mu} + \phi + \frac{3}{2\mu}\right) \quad (10)$$

In order to determine the condition of minimum strain energy, Equation 10 must be evaluated with the aid of Equation 1, where $\mu\phi$ is the most effective factor in the torque transmission capacity. For the case where the transmission torque capacity is limited by the stress in the bridging coil, the maximum effective $\mu\phi$ has been attained in

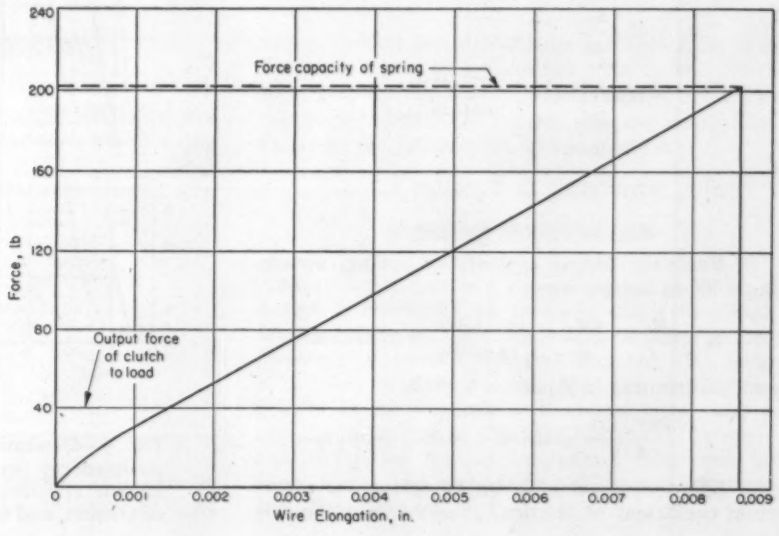


Fig. 2—Typical force-elongation curve of wire at bridging-coil end of effective angle of wrap.

less than the full number of coils. Consequently, an increase in the coefficient of friction affects only the denominator terms to make the value of bracket of Equation 10 a minimum. The bracketed term is plotted in Fig. 4 against ϕ for the coefficients of friction 0.1, 0.15, and 0.2. If the clutch must transmit an output load in addition to the output shaft acceleration, the dynamic strain energy is reduced by the area shown under the output force line in Fig. 2.

Example: To illustrate the steps required for calculating the net dynamic strain energy, assume the following requirements and conditions for a spring clutch to act as the coupling element for a one-revolution clutch.

$D_d = 1$ in. $\quad T_o = 20$ lb-in.
$I_i = 80 \times 10^{-4}$ in-lb-sec^2 $\quad t = 0.003$ sec
$I_o = 2 \times 10^{-4}$ in-lb-sec^2 $\quad \mu_{max} = 0.20$
$I_r = 0.1 \times 10^{-4}$ in-lb-sec^2 $\quad \mu_{min} = 0.05$
$S_w = 110{,}00$ psi $\quad$ Speed $= 1000$ rpm

The following steps outline the solution of this problem.

1. *Minimum torque capacity* required:

$$T_g = T_o + I_o \frac{\Delta\omega}{\Delta t}$$

$$= 20 + (2 \times 10^{-4}) \left[\frac{2\pi(1000)}{60(0.003)} \right]$$

$$= 27 \text{ lb-in.}$$

2. *Minimum interference moment* required is determined in several operations. Assume 10 turns per drum and $\mu = 0.05$. From Equation 1,

$$M = \frac{T_g}{e^{\mu\theta} - 1} = \frac{27}{e^{\pi} - 1} = 1.23 \text{ lb-in.}$$

where

$$\mu\theta = (0.05)(2\pi)(10) = \pi$$

From Equation 2, M_c is negligible. From Equation 3,

$$M_r = 2I_r \frac{\Delta\omega}{\Delta t}$$

$$= 2(0.1)(10^{-4}) \left[\frac{2\pi(1000)}{60(0.003)} \right]$$

$$= 0.70 \text{ lb-in.}$$

Finally, substituting in Equation 4,

$$M_t = 1.23 + 0.70 = 1.93 \text{ lb-in.}$$

3. *Maximum torque capacity* of spring, assuming 0.060-in. square wire:

$$S_b = \frac{Mc}{I} = \frac{6M_t}{k^3} = \frac{(6)(1.93)}{(0.060)^3} = 53{,}500 \text{ psi}$$

and, substituting in Equation 5,

$$T_s = \frac{(0.060^2)(1)}{2} (110{,}000 - 53{,}000) = 101 \text{ lb-in.}$$

4. *Effective angle of wrap* of spring for maximum coefficient of friction, $\mu = 0.2$, and the fol-

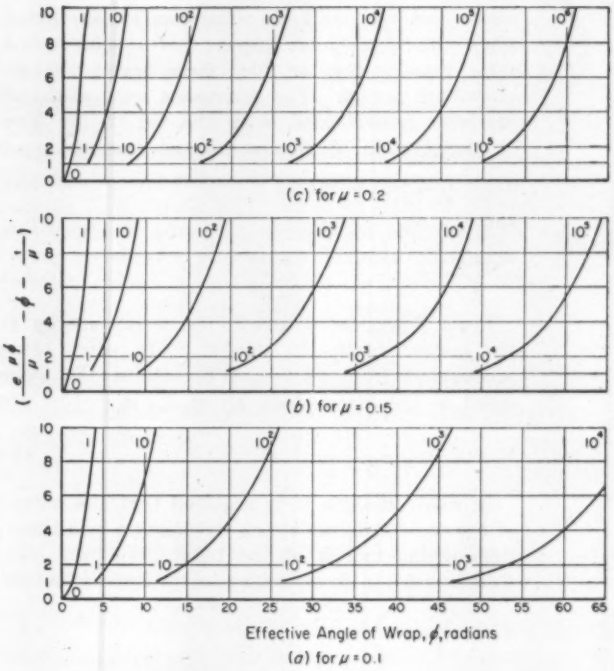


Fig. 3—Wire elongation for known effective angle of wrap and coefficient of friction.

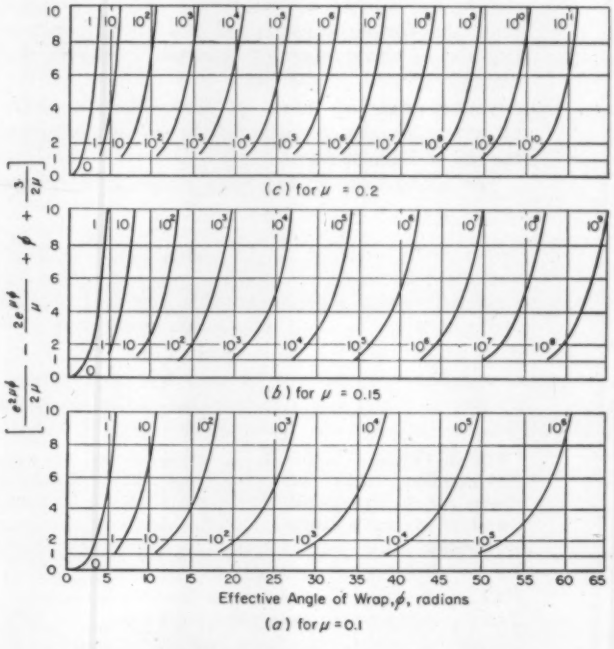


Fig. 4—Determination of bracketed term in strain-energy expression, Equation 10, for known effective angle of wrap, coefficient of friction, and wire elongation.

lowing loading conditions:
Maximum torque capacity, $T_s = 101$ lb-in.,

$$e^{\mu\phi} = \frac{T_s + M_t}{M_t} = \frac{101 + 1.93}{1.93} = 53.3$$

$$\mu\phi = 3.98$$

$$\phi = \frac{3.98}{0.2} = 19.9 \text{ radians}$$

Torque load of output shaft, $T_o = 20$ lb-in.

$$e^{\mu\phi} = \frac{T_1 + M_t}{M_t} = \frac{20 + 1.93}{1.93} = 11.35$$

$$\mu\phi = 2.43$$

$$\phi = 12.15 \text{ radians}$$

5. *Wire elongation* at bridging coil for maximum coefficient of friction under the following conditions:
Maximum torque capacity, $T_s = 101$ lb-in. Substituting proper values in Equation 9, and referring Fig. 3*c* for $\phi = 19.9$,

$$L_s = \frac{2M_t}{AE}\left(\frac{e^{\mu\phi}}{\mu} - \phi - \frac{1}{\mu}\right)$$

$$= \frac{(2)(1.93)}{(0.060^2)(30 \times 10^6)}(241)$$

$$= (3.58 \times 10^{-5})(241) = 0.0086\text{-in.}$$

Torque load of output shaft, $T_o = 20$ lb-in. See Fig. 3*c* for $\phi = 12.15$. Then,

$$L_1 = (3.58 \times 10^{-5})(40) = 0.0014\text{-in.}$$

6. *Strain energy* of spring for maximum coefficient of friction.
Maximum torque capacity, $T_s = 101$ lb-in. See Fig. 4*c* for $\phi = 19.9$. Substituting in Equation 10,

$$N_s = \frac{(1.93^2)(4)}{(0.060^2)(30 \times 10^6)(1)}(6600)$$

$$= (137 \times 10^{-6})(6600) = 0.907 \text{ in-lb}$$

Torque load of output shaft prior to shaft motion. See Fig. 4*c*, for $\phi = 12.15$. Then,

$$N_{1\text{-}1} = (137 \times 10^{-6})(230) = 0.032 \text{ in-lb}$$

Energy consumed by output shaft load during shaft motion:

$$N_{1\text{-}2} = \frac{2T_1}{D_d}(L_s - L_1) \qquad (11)$$

$$= \frac{2(20)}{1}(0.0086 - 0.0014) = 0.288 \text{ in-lb}$$

Net strain energy available for acceleration of output shaft:

$$N_n = N_s - N_{1\text{-}1} - N_{1\text{-}2} \qquad (12)$$

$$= 0.907 - 0.032 - 0.288 = 0.587 \text{ in-lb}$$

Strain energy required for acceleration of output shaft. Substituting in Equation 8,

$$N_o = \frac{2(10^{-4})}{2}\left[\frac{80 \times 10^{-4}}{(80 + 2)10^{-4}}\right]\left[\frac{2\pi(1000)}{60}\right]^2$$

$$= 1.06 \text{ in-lb}$$

The 0.060-in. square wire does not fully meet the strain-energy requirements of this design. Another trial calculation for 0.065-in. square wire increases the resulting strain energy available for acceleration of output shaft to 1.13 in-lb which meets the design requirements. The diametral interference for this spring is

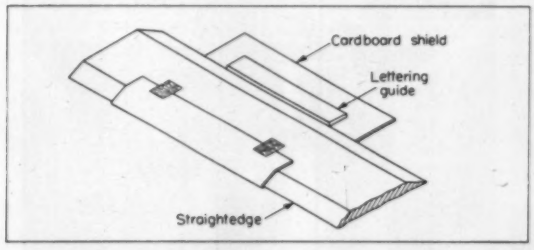
$$\delta = \frac{6M_t(D_d^2)}{E(k^4)} \qquad (13)$$

$$= \frac{6(1.93)(1^2)}{(30 \times 10^6)(0.065^4)} = 0.0217 \text{ in.}$$

Tips and Techniques

Keeping Drawings Clean

When using a LeRoy or similar lettering set, shifting the guide back and forth on the drawing



usually soils or marks the paper. This can be prevented by folding a piece of cardboard or light plastic around the straightedge, as shown, so that the guide slides on this rather than on the drawing. This will effectively prevent soiling the drawing paper.—FRED C. POLITZ, *job engineer, Alco Products Inc., Beaumont, Tex.*

Sketching Modifications

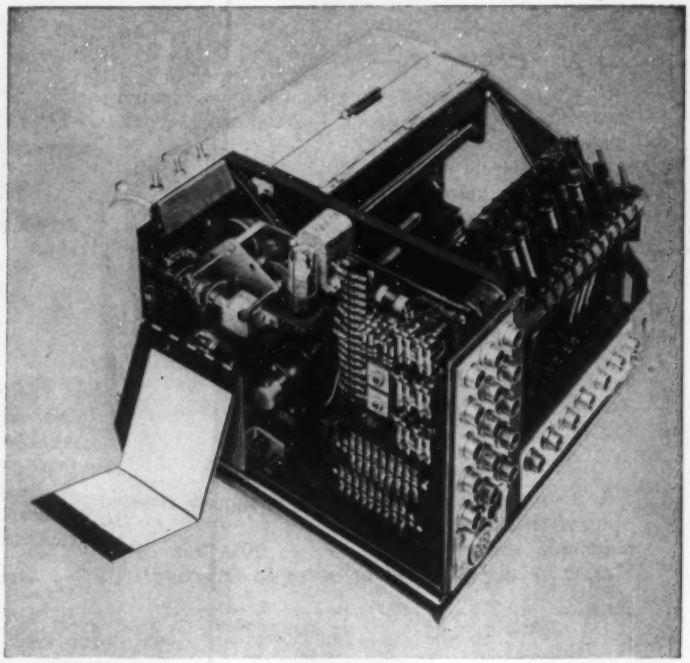
Many times during a group meeting in which a design is discussed, an occasion arises to sketch modifications or additions. This means the use of many prints or destructive erasures. By using a cellulose acetate overlay, such as half of an 8½ by 11 in. transparent loose-leaf cover, and a pen, modifications or additions can readily be made and shifted or rotated as desired.—KENNETH G. LEIB, *senior engineer, Sylvania Electric Products Inc., Kew Gardens, N. Y.*

Easy-Access Oscillograph Design Simplifies Operation and Maintenance

Hinged access doors and a removable cover, which is held on with only three fasteners, make it easy to inspect, operate and service the PM-20 general-purpose oscillograph made by General Electric. Capable of recording 71 individual variables on one oscillogram, the unit is designed with two separate galvanometer mounts, permitting simultaneous use of both wound-coil and bifilar galvanometers.

The instrument is equipped with an automatic shutter that closes as the record holder, which holds 100 ft of paper, is released from the oscillograph. This reduces the possibility of fogging records during transportation.

It is easy to make electrical connections to unit since the connector receptacles are centrally located and clearly identified.



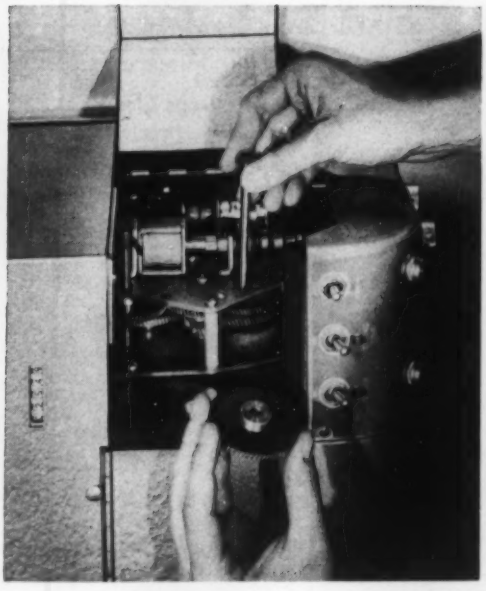
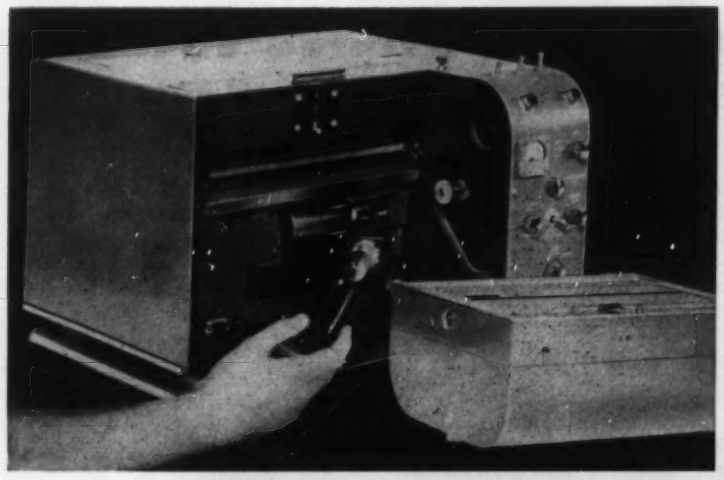
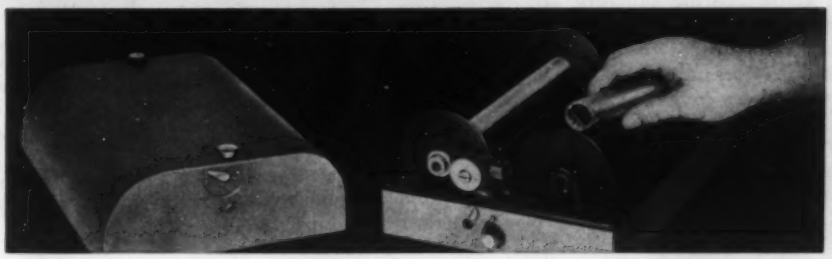


Chart speeds are changed over a 2-to-1 speed range by turning a knob on a governor-controlled motor. When a greater speed change is required, one of two interchangeable color-coded idler gears is moved to a new position. This is accomplished without tools, and only seven interchanges are needed to cover the entire speed range of 4 to 500 fpm. Noise is minimized by using helical gears that are mated, nylon to aluminum.



The two lamps are easily accessible when record holder is removed. Lamp holders swing out for convenient removal of either lamp. Separate viewing and recording lamps are used to reduce number of adjustments in intensity of the recording lamp.

Alnico magnets in ends of spools make possible rapid, snap-in positioning of film spools. This feature eliminates fumbling in the darkroom when loading photographic paper.

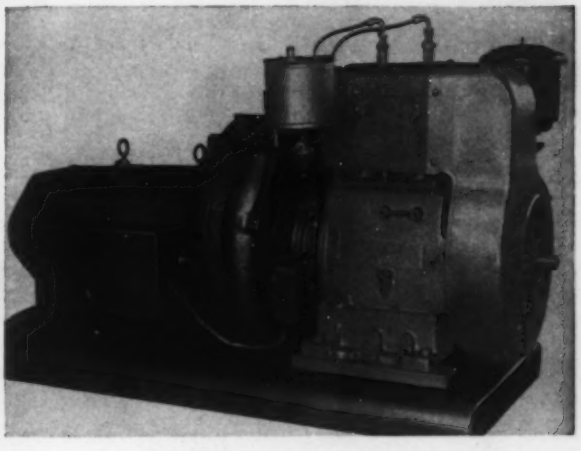


Generator Automatically Driven by Electric Motor or Gasoline Engine

A new 5 kw electrical power supply consists of a special motor-generator set directly connected to a large flywheel, a magnetic clutch and an internal combustion engine. The Micro Power standby power unit regulates line voltage during normal operation and provides uninterrupted emergency power the instant the regular source fails.

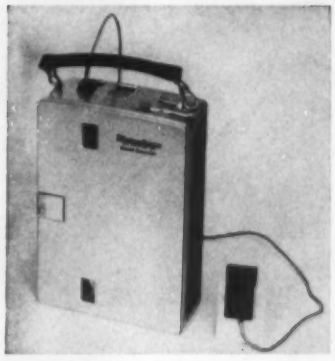
During normal operation, output power is obtained from the motor-driven alternator. In the event of a power failure, the magnetic clutch automatically engages the motor-alternator-flywheel shaft to the gasoline engine. Before the voltage drops below a safe value, flywheel momentum starts the engine and smoothly powers the alternator until fully engine driven. When electric power is restored, the engine is automatically disengaged, and stopped. Again flywheel momentum smoothly drives the alternator during the return to the motor drive.

The motor-generator set is made by Leland Electric Co. Div., American Machine & Foundry Co. The rest of the unit is assembled by U. S. Motors Corp.



Magnesium Parts and Printed Circuits Minimize Recorder Size and Weight

In a new portable dictating machine developed by Dictaphone Corp., magnesium parts are used extensively to provide maximum rigidity and ruggedness with minimum weight. Magnesium die castings are employed for the case and cover, and the complex tape-holding magazine. The housing for the reversible magazine is made from two identical halves that have a minimum wall thickness of 0.060-in.



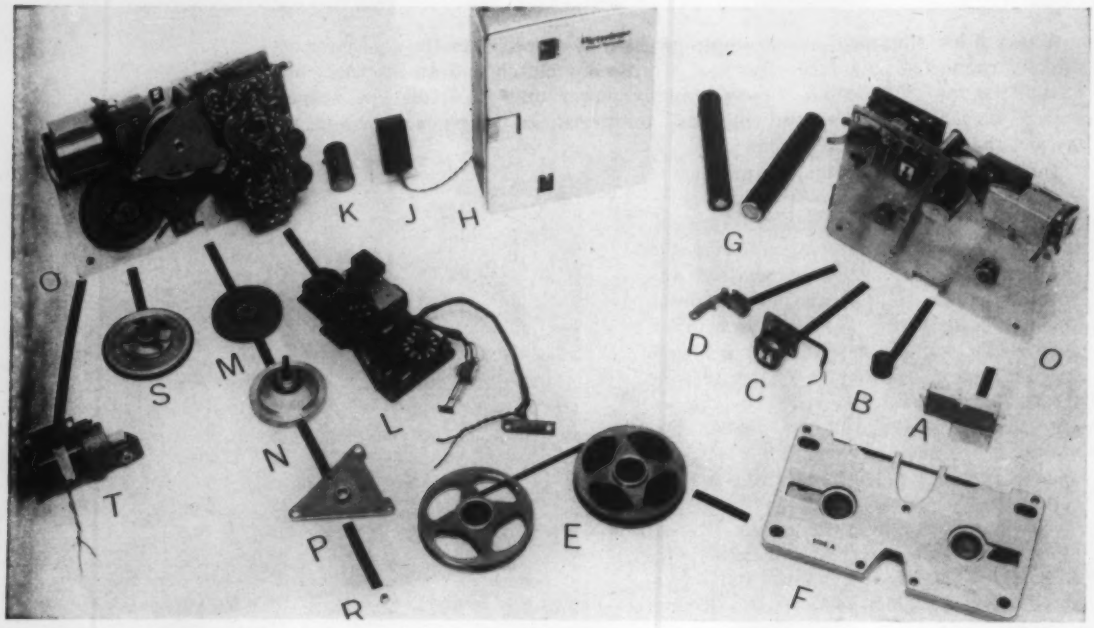
Several operating parts in this recording unit, known as the Dictet, are fabricated from magnesium including three wheels and a gear box. Other magnesium parts include a belt chute, a carriage, motor bearing supports, etc.

The basic mechanism is built onto a thin stainless-steel plate which is fastened in the case with a three-point suspension. On this plate is mounted the transistorized printed-circuit amplifier that also offers weight-reduction advantages and prolongs battery life. The batteries power both the motor and amplifier.

Spring-loaded drag brakes are provided to prevent spilling of the tape when the magazine is removed from the machine. The magazine contains two reels, each 2⅝ in. diameter, and holds 396 ft of ¼-in. by 0.0006-in. Mylar magnetic recording tape. Closed loops are provided on each end of the tape, to assure that the tape will remain threaded when fully wound in either direction.

The machine is equipped with self-aligning spindles to facilitate insertion of the magazine. A single function lever permits selection of recording, playback or rewind. Start and stop control is provided with a separate on-off switch. When the function switch is placed in the rewind position, a mechanical interlock actuates the on-off switch.

A. Motor noise filter
B. Tape drive wheel
C. Recorder-reproducer head
D. Erasing head
E. Reels of magnetic recording tape
F. Tape magazine
G. Motor batteries
H. Dictet recorder
J. Lapel microphone
K. Amplifier battery
L. Amplifier
M. Drive gear
N. Flywheel and capstan
O. Unit plate
P. Bearing plate and jewel bearing
R. Jewel bearing
S. Take-up spindle
T. Motor assembly



Predicting strength and dimensions of

Adhesive Joints

By Harold Tombach
Aeronautical Engineer
Hughes Tool Co.
Aircraft Div.
Culver City, Calif.

Adequacy of any adhesive joint for bonding metals is largely determined by its strength. Strength, in turn is greatly influenced by the bond area and may be predicted by a number of theoretical or empirical methods. The four most useful formulas are presented in detailed form with the advantages and disadvantages of each pointed out. All are based upon the simple lap joint.

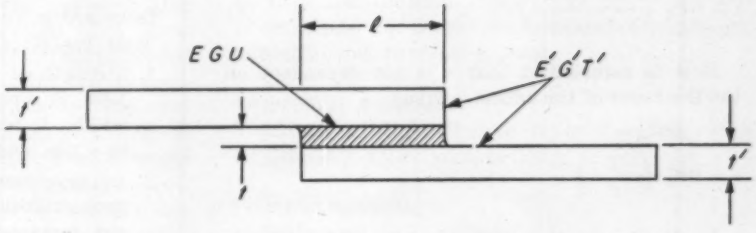


Fig. 1—Adhesive-bonded simple lap joint. Adhesive layer thickness t is exaggerated for clarity.

Nomenclature

E = Modulus of elasticity for adhesive layer, psi
E' = Modulus of elasticity for adherend, psi
G = Modulus of rigidity for adhesive layer, psi
G' = Modulus of rigidity for adherend, psi
l = Length of joint overlap, in.
P = Failing load in tension shear of a joint of unit width, lb per in.
p' = Tensile stress of adherend away from the bonded area at joint failure, psi
s = Adhesive layer mean failing stress in tension shear (equal to failing load in tension shear divided by bond area), psi
T' = Tensile strength of adherend, psi
t = Thickness of adhesive layer, in.
t' = Thickness of adherend, in.
U = Shear strength of adhesive layer, psi
ν' = Poisson's ratio of adherend

ADHESIVE bonding is a popular means of joining parts of an assembly. Among bonded structural joints the simple lap joint, Fig. 1, is the most important. It is widely used, and many other joints may be reduced to a set of simple lap joints for the purpose of strength estimation.

Methods covered in this article are for simple lap joints between adherends of the same material and thickness. These methods are used primarily for bonds between metals. They should, however, also be useful in predicting bond strength between nonmetallic materials, provided the assumptions at the basis of each method are satisfied with sufficiently close approximation. An extension of these methods to simple lap joints between adherends of differing thickness and even of differing characteristics is possible but is beyond the scope of this article.

While mechanical constants of adherends are readily available, this information is generally lacking for the adhesive layer. Therefore, it cannot be expected that the strength of an adhesive-bonded joint may be accurately predicted without a substantial amount of experimental work.

Usefulness of the methods to be described lies in the reduction of the amount of this experimental work. Cut-and-try methods may be justified in the design of a single joint. However, when the number of joints is large, the use of established empirical and theoretical relationships between the various bond parameters will prove to be more economical.

STRENGTH DETERMINATION

If the average failing stress s of the bond is known, the strength of a joint of unit width is given by

$$P = sl \tag{1}$$

To obtain the strength of a joint of given width, it is only necessary to multiply P by this width.

Considerations of dimensional analysis, assuming that $l, t, t', E, G, U, E', \nu'$ are all the parameters on which the average failing stress s depends, establish

$$s = UF_1\left(\frac{l}{t}, \frac{l}{t'}, \frac{E}{E'}, \frac{G}{E'}, \frac{s}{E'}, \nu'\right) \tag{2}$$

If bonds made only with a particular adhesive between one type of adherend by a specific bonding process are considered

$$s = UF_2\left(\frac{l}{t}, \frac{l}{t'}\right) \tag{3}$$

If it is established that s is not dependent on the thickness of the adhesive layer

$$s = UF_3\left(\frac{l}{t'}\right) \tag{4}$$

In these equations, F_1, F_2, F_3 are arbitrary functions of the indicated dimensionless parameters or of any products of these parameters by other dimensionless parameters.

The form of these functions has to be determined either empirically or by analytical methods. Procedures used in four approaches to this problem will be described. The first two procedures, A and B, are purely empirical, while the last two, C and D, are based on theoretical analysis.

Although the degree of theoretical justification is not the same for all four methods, one cannot give general preference to any one from the viewpoint of accuracy in predicting the strength of a given simple lap joint. Depending on the particular combination of adhesive, adherend and bonding process, one or another of the four methods may give best results. Each is described in detail later.

GENERAL OBSERVATIONS

Strength values obtained may be safely applied only if the bonding process for actual parts produces bonds of the same quality as the test joints which establish the empirical design curves or mechanical constants of the adhesive bond. This means that a production process assuring uniform bond properties must be established before any test specimens are prepared.

Although theoretical considerations would indicate that Method C is more satisfactory with supported joints and Method D better for joints able to bend, experimental evidence[1] does not seem to justify this distinction in practice.

If the actual joint is supported, the strength values obtained by the methods described are likely to be on the conservative side. This is because of the absence of peeling stresses which are present when the joints are tested in the conventional

[1]References are tabulated at end of article.

EMPIRICAL FACTS

Methods used for determining the strength of a metal-to-metal adhesive bond are based upon a number of assumptions. These assumptions or empirical facts have been largely substantiated by experimentation. However, they should not be considered as proven facts with precisely determined characteristics. The methods described have been evolved from indications that the following facts are sufficiently accurate to serve as a basis for strength determination.

1. Strength of an adhesive-bonded simple lap joint is directly proportional to the joint width. A 2-in. wide joint is twice as strong as a 1-in. wide joint.
2. Adhesive-bonded lap joint strength is not proportional to the length of the overlap, but increases at a slower rate than the overlap and tends toward a finite maximum. A joint with a 2-in. overlap is less than twice as strong as a joint with a 1-in. overlap and a 5-in. overlap may not produce an appreciably stronger joint than a 3-in. overlap.
3. Strength of a lap joint is a function of the stiffness of the jointed members; stiffer members produce stronger joints. A joint between 0.081-in. aluminum members is stronger than a joint between 0.032-in. aluminum, and a joint between 0.032-in. stainless-steel members is stronger than that between 0.032-in. aluminum.
4. Joint strength depends on the type of adhesive and on the bonding process used.
5. Strength of an adhesive bond is usually a function of adhesive layer thickness, although the relationship is not clearly established and seems to vary with the circumstances.
6. The extent of the influence upon the average tension-shear failing stress of the adhesive bond by the geometrical parameters of the joint depends on the relative magnitude of the elastic constants of adhesive and adherend. The more flexible the adhesive in comparison to the adherend, the less the average failing stress is influenced by the geometrical configuration of the joint.

manner, as assumed in this article.

In some cases better agreement may be obtained between experimental data and computed strengths by determining separate sets of empirical constants (a, b, U, G) for narrow ranges of the geometrical parameters instead of covering a wide range of joint-overlap lengths and adherend thicknesses in a single statistical treatment.

In simple lap joints loaded in tension, the maximum stress is located at the ends of the overlap. If bending of the joint occurs, maximum tear stresses appear at the same location. The strength of a simple lap joint can be effectively increased by reinforcements (rivets) at the overlap ends, by reducing the bending ability of the joint, or both.

Since the mechanical constants of adhesives usually vary considerably with the temperature, separate sets of experimental data and separate loads should be obtained for the extremes of temperatures contemplated during the service of the joint.

All the design methods discussed use more or less valid approximations of the unknown true relationship between the parameters of a given adhesive-bonded simple lap joint. Furthermore, the indicated methods of determining the mechanical constants of the adhesive layer are also very approximate. It is thus not surprising that agreement between predicted and actual joint strength is not always perfect, varying with each particular combination of strength prediction method, adherend, adhesive and bonding process.

It is also known that adhesive bonds produced under conditions which appear to be identical often exhibit greatly differing strengths. The failing stresses determined by any of the methods described must therefore be reduced by an adequate safety coefficient. This safety coefficient should be determined by the suitability of the chosen design method for the specific application, the reliability of the particular adhesive and bonding process as determined by statistical analysis of the basic test data, the degree of control of the bonding process of actual parts as compared to the control executed in the bonding of the test specimens, and the structural importance of the joint.

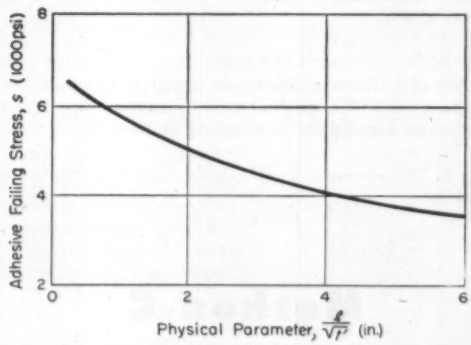


Fig. 2—General shape of curve giving failing stress of adhesive layer as established by the stress formula used in method A.

Method A

CHARACTERISTICS OF METHOD

Dimensionless Parameter

$$\sqrt{\frac{l}{t}\,\frac{l}{t'}} = \frac{l}{\sqrt{tt'}}$$

Stress Formula[2]

$$s = f\left(\frac{l}{\sqrt{t'}}\right) \qquad (5)$$

In this formula the dimensional parameter $l/\sqrt{t'}$ is substituted for the dimensionless parameter $l/\sqrt{tt'}$ because t is assumed to be constant. The form of the function f has to be determined experimentally for each combination of adherend, adhesive and bonding process.

Theoretical Assumption

Thickness of the adhesive layer does not vary significantly from joint to joint.

Practical Advantages

1. No tedious computations.
2. No need for delicate measurement of adhesive layer thickness.

PROCEDURE

Step 1: Select appropriate adhesive and establish in detail the bonding process to be used in the manufacture of the actual assemblies: adherend cleaning procedure, adhesive application particulars, bonding temperature, bonding pressure, curing time, etc.

Step 2: Prepare a large number of simple lap test specimens using the same adherend, the same adhesive, and the same bonding process as in the manufacture of the contemplated assemblies. It is convenient to make all specimens the same width (1 in.) but overlap length and adherend thickness must be varied. For each adherend thickness prepare specimens with several overlap lengths. Extreme values of both variables must encompass the whole range of values to be used in design, since extrapolation of test results is usually not safe practice.

It is advisable to bond larger panels and cut the individual test specimens from these panels after bonding.[3,4]

Determine the thickness of the adhesive layer of each test specimen. This can be done by measuring the adherend thickness before bonding and the thickness of the completed bond. The difference between the latter value and the sum of the thicknesses of the two adherend strips may be accepted as the thickness of the adhesive layer. For Method A and B, this is useful in interpreting possible discrepancies in test results, and also will shed some light on the ability of the chosen bonding process to produce bonds of sufficiently uniform thickness. For Method C and D, this

thickness is necessary for the calculations involved. A precision of 0.0001-in. in measuring the thicknesses is suggested for ordinary applications.

Step 3: Determine the failing load P of these specimens by testing them in tension shear in the conventional manner.[3,4]

Step 4: Compute the average failing stress in tension shear s of each specimen by dividing the load at failure by the area of the bond. The latter should be measured for both length and width with a precision of at least 0.010-in.

Retain only those values of s which correspond to failures of the adhesive bond, eliminating values obtained from test specimens that failed through rupture of the members outside the bonded area.

Step 5: Plot the curve for the stress formula, $s = f(l/\sqrt{t'})$. Because of the usually large variability of test results on adhesive bonds, it is advisable to use statistical methods for this plot (see Appendix, Section 1). In addition to establishing the average curve it is useful to calculate the deviations from this curve for different probabilities of occurrence. The general shape of the curve is given, Fig. 2. The numerical data are different for different combinations of adhesive, adherend, and bonding process. Sometimes instead of being plotted against $l/\sqrt{t'}$, s is plotted against the reciprocal of this quantity, $\sqrt{t'}/l$, called the "joint factor."

Step 6: To determine the strength of a joint with a given overlap length and adherend thickness, compute the parameter $l/\sqrt{t'}$ and read failing stress from the curve established in Step 5. Since the parameter $l/\sqrt{t'}$ is not dimensionless, it is important to observe that the same units are used, i.e., in., cm, mm, etc.

Step 7: The strength P of a joint of unit width is given by

$$P = sl$$

Method B

CHARACTERISTICS OF METHOD

Dimensionless Parameter

$$\frac{l}{t'}$$

Stress Formula[5]

$$s = a\left(\frac{l}{t'}\right)^{-b} \qquad (6)$$

The positive constants a and b have to be determined experimentally for each combination of adherend, adhesive, and bonding process.

Theoretical Assumption

s is independent of adhesive layer thickness t.

Practical Advantages

1. No tedious computations.
2. No need for the bonding process to produce constant adhesive layer thicknesses, as long as the latter stay within limits for which the theoretical assumption is valid.
3. Possibility of rapid determination of maximum useful length of overlap for a given tensile strength of the adherend by the use of the relationship

$$p't' = sl$$

which gives, if p' is made equal to T',

$$l = t'\left(\frac{T'}{a}\right)^{1/1-b} \qquad (7)$$

With this or a longer overlap, the joint should fail through tensile rupture of the adherend.

Steps 1 through 4: Same as for Method A.

Step 5: Fit the straight line $s = a(l/t')^{-b}$ to the experimental points plotted on logarithmic paper. Use statistical fitting techniques if points are widely scattered (see Appendix, Section 2). Fitting by hand is sometimes facilitated by expressing s as a function of $(l/t')^2$ instead of (l/t'). In the latter case, the equation of the straight line on logarithmic paper becomes

$$s = a\left[\left(\frac{l}{t'}\right)^2\right]^{-\beta}$$

Since

$$\log s = \log a - b\log\left(\frac{l}{t'}\right) =$$

$$\log a - \beta\log\left(\frac{l}{t'}\right)^2$$

the values of the positive coefficients a and b or β are given respectively by the value of s for $l/t' = 1$ and the slope of the straight line. The general shape of the curve for

$$s = a\left[\left(\frac{l}{t'}\right)^2\right]^{-\beta}$$

is shown in Fig. 3.

It may be more advantageous to plot $p' = f_1(l/t')$ instead of $s = f(l/t')$. The passage from one relationship to the other is easily accomplished since

$$p't' = sl$$

From which follows

$$p' = a\left(\frac{l}{t'}\right)^{1-b}$$

or

$$p' = a\left[\left(\frac{l}{t'}\right)^2\right]^{1/2-\beta}$$

again yielding straight lines if plotted on logarithmic paper. The general shape of the curve for p' is also shown in Fig. 3.

Step 6: To determine the strength of a joint of given overlap and adherend thickness, compute the parameter (l/t') or $(l/t')^2$ and read failing stress from one or another of the curves established in Step 5.

Step 7: The strength P of a joint of unit width is then given by

$$P = sl = p't'$$

Method C

CHARACTERISTICS OF METHOD

Dimensionless Parameter

$$\sqrt{\frac{l}{t'}\frac{l}{t'}\frac{G}{E'}} = l\sqrt{\frac{G}{tt'E'}}$$

Stress Formula[6]

$$s = \frac{U}{\frac{1}{K_e}\coth\frac{1}{K_e}} \qquad (8)$$

where

$$\frac{1}{K_e} = l\sqrt{\frac{G_e}{2\,E'tt'}} \qquad (9)$$

The mechanical constants U and G_e and the thickness t of the adhesive layer have to be determined for each combination of adhesive and bonding process, while E' is usually known.

Theoretical Assumptions

1. No bending of the joint occurs.
2. Stresses in adhesive and adherend do not exceed the elastic limits.
3. Shear stress is constant across the thickness of the adhesive layer.
4. Adhesive layer strain in the direction of its thickness is negligible.
5. Adhesive and adherend are isotropic.

Practical Advantages

1. Results obtained on one adherend are transferable to any other adherend provided equally good adhesion is obtained in both cases. This has to be verified experimentally.
2. Computations are relatively simple if use is made of the curve of Fig. 4.

PROCEDURE

Steps 1 through 4: Same as for Method A.

Step 5: For each adherend thickness plot a curve $s = f(l)$. Extrapolate each curve to a common intercept with the stress axis $l = 0$. The value of s at this common intercept is the apparent shear strength, U, Fig. 5. For better accuracy use statistical techniques to determine the values of the common intercept (see Appendix, Sertion 3).

The value of U thus obtained does not represent the true shear strength of the adhesive layer. It is but an empirical constant to be used in Equation 8. The true shear strength of the adhesive layer is likely to be different because the theoretical assumptions of this method, in particular Assumptions 1 and 2, are not satisfied.

Step 6: For each experimental point calculate the stress concentration factor U/s. According to Equation 8 this is equal to $(1/K_e)$ coth $(1/K_e)$. From the curve, Fig. 4, which correlates $(1/K)$ coth $(1/K)$ with K, read on the K scale the values of K_e corresponding to the computed values of U/s. Calculate also the corresponding values of $\sqrt{tt'}/l$.

Step 7: Plot the scatter diagram $\sqrt{tt'}/l$ versus K_e. Fit a straight line through the origin of the co-ordinates. Use statistical fitting techniques in case of wide scatter (see Appendix, Section 4).

According to Equation 9,

$$\frac{\sqrt{tt'}/l}{K_e} = \sqrt{\frac{G_e}{2\,E'}}$$

Thus the slope of the fitted straight line is $\sqrt{G_e/2E'}$. Since E' is known or can be easily determined, the apparent modulus of rigidity G_e of the adhesive layer is found.

This value of G_e is not the true modulus of rigidity of the adhesive layer but is merely an empirical constant for use in Equation 9. Due to the testing procedure, the theoretical assumptions, especially Assumptions 1 and 2, are unsatisfied. Thus one should not consider G_e an intrinsic constant of the adhesive layer: $G_e \neq G$.

Step 8: The average failing shear stress of a joint of given overlap length and adherend thickness can now be computed from Equations 8 and 9 by substituting for t an average value deducted from test results.

Equation 8 may in some cases also be applied to estimate the strength of joints between adherends other than the adherend used in establishing the adhesive constants U and G_e, simply by substituting the appropriate value for E'.

However, this extension can be justified only if the bonding properties of the new adherend equal those of the original adherend. This assumption has to be

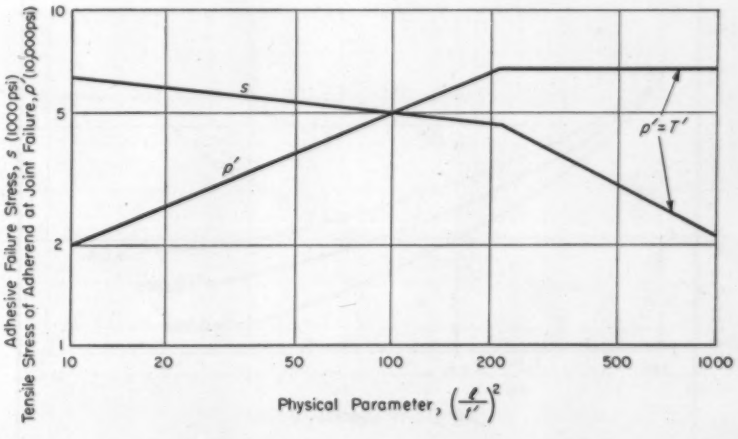


Fig. 3—General shape of curves for failing stress of adhesive and separation of adhesive from adherend when drawn on logarithmic paper.

thoroughly verified experimentally.

Step 9: The strength P of a joint of unit width is then given by

$$P = sl$$

Method D

CHARACTERISTICS OF METHOD

Dimensionless Parameters

$$\left(\frac{l}{t}, \frac{l}{t'}, \frac{G}{E'}\right) = l\sqrt{\frac{G}{tt'E'}}$$

$$\left(\frac{l}{t'}\right)^{3/2}\left(\frac{s}{E'}\right)^{1/2} = \frac{l}{t'}\sqrt{\frac{p'}{E'}}$$

Stress Formula[7]

$$s = \frac{U}{\left(\frac{1+3c}{4}\right)\left(\frac{2}{K_d}\right)\coth\frac{2}{K_d} + \frac{3(1-c)}{4}} \qquad (10)$$

where

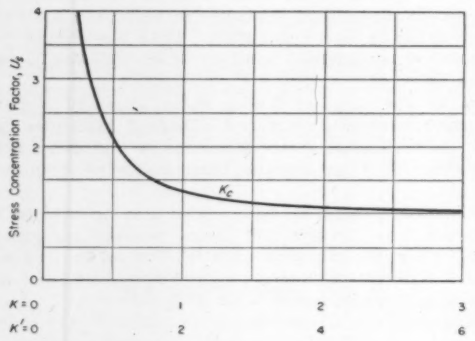


Fig. 4—Analytical curve for correlation of the stress concentration factor to empirical constants K and K'.

$$\frac{1}{K_d} = l\sqrt{\frac{G_d}{2E'tt'}} \qquad (11)$$

$$\frac{1}{c} = 1 + 2\sqrt{2}\tanh\left[\left(\sqrt{\frac{3}{2}(1-\nu'^2)}\right)\left(\frac{l}{2t'}\sqrt{\frac{p'}{E'}}\right)\right] \qquad (12)$$

The elastic constants U and G_d and the thickness t of the adhesive layer have to be determined for each combination of adhesive and bonding process, while E' and ν' are usually known.

Theoretical Assumptions

1. The joint is free to bend.
2. Stresses in adhesive and adherend do not exceed the elastic limits.
3. Deformation of adherend in the bonded area is caused solely by the longitudinal normal stress.
4. Transverse normal strain and shear strain in the adherends are negligibly small.
5. Longitudinal normal stress in adhesive layer is negligible.
6. Other stresses in adhesive layer do not vary across the thickness of the layer.
7. The adhesive layer is comparatively flexible so that

$$\frac{t'}{E'} < \frac{t}{10E}, \frac{t'}{G'} < \frac{t}{10G}$$

which is generally the case with adhesive-bonded metal joints.

8. Adhesive and adherend are isotropic.

Practical Advantages

Results obtained with one adherend are readily transferable to any other adherend provided equally good adhesion is obtained in both cases.

PROCEDURE

Steps 1 through 4: Same as for Method A.

Step 5: The value of U is obtained in the same manner as described under Step 5 of Method C.

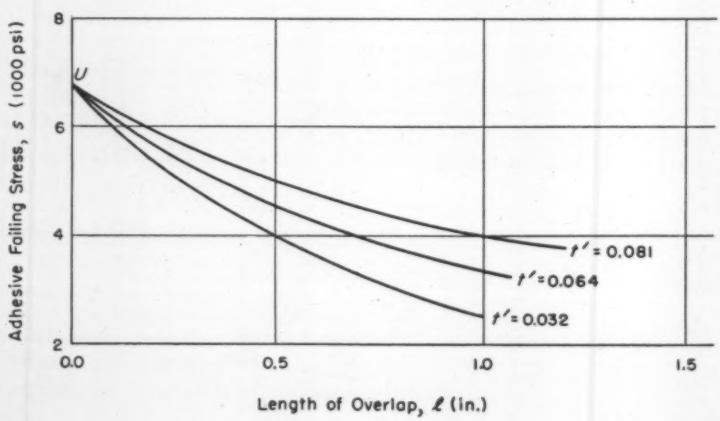


Fig. 5—Estimation of U as the common intercept of the family of curves for the stress formula of Method C as plotted for various adherend thicknesses, t'.

Step 6: For each test specimen determine the value of the parameter $(l/t')\sqrt{p'/E'}$. From this a plot should be constructed to give values of c from

$$c = 1 + 2\sqrt{2}\tanh\left[\left(\sqrt{3-3\nu'^2}\right)\left(\frac{l}{2t'}\right)\left(\sqrt{\frac{p'}{E'}}\right)\right]$$

The corresponding value of the parameter c for the usual case of $\nu' = 0.3$ is given[7], Fig. 6.

For each experimental result compute the value of

$$\frac{4}{1+3c}\left(\frac{U}{s} - \frac{3(1-c)}{4}\right)$$

From Equation 10 it may be seen that this is equal to

$$\frac{2}{K_d}\coth\frac{2}{K_d}$$

and the corresponding values of K_d may be read from the K' scale, Fig. 4.

Calculate the values of $\sqrt{tt'}/l$ for each test specimen.

Step 7: Determine G_d in the same way as G_e is determined in Step 6 of Method C, by correlating $\sqrt{tt'}/l$ with K_d. Again G_d is only the apparent shear strength, as determined by this method, and not the true shear strength of the adhesive layer: $G_d \neq G_e \neq G$.

Step 8: To determine the average shear failing stress of a joint of given overlap between adherends of given thickness, it is necessary to work by successive approximations because, as may be seen from Equations 10 and 12, s is also a function of

$$p' = \frac{sl}{t'}$$

through parameter c. For t substitute an average value deduced from the test data.

The applicability of this method to adherends other than the one used in establishing the values of U and G_d is subject to the restriction discussed in Step 8 of Method C.

Step 9: Once s has been determined for a particular joint, its strength per unit width is given by

$$P = sl$$

Appendix—Statistical Techniques

Section 1

For the curve $s = f(l/\sqrt{t'})$ in Method A, Step 5.

If the regression line of s on $x = l/\sqrt{t'}$ may be assumed to be of the form, $s = ax^2 + bx + c$, the numerical values of the coefficients a, b, c can be estimated by the method of least squares from the solution of the three normal equations,

$$\sum_j (s_j - ax_j^2 - bx_j - c)x_j^2 = 0$$

$$\sum_j (s_j - ax_j^2 - bx_j - c)x_j = 0$$

$$\sum_j (s_j - ax_j^2 - bx_j - c) = 0$$

where x_j, s_j are any pair of observed values of x and s and the summation is extended to all values obtained in the test series.

Section 2

For the curve $s = a(l/t')^{-b}$ or $s = a[(l/t')^2]^{-b}$ in Method B, Step 5.

A regression equation of s on x of the form $s = ax^{-b}$ [$x = l/t'$ or $x = (l/t)^2$] will produce a straight line on logarithmic paper: $\log s = \log a - b \log x$. The numerical values of the positive coefficients a and b can be estimated by the method of least squares from

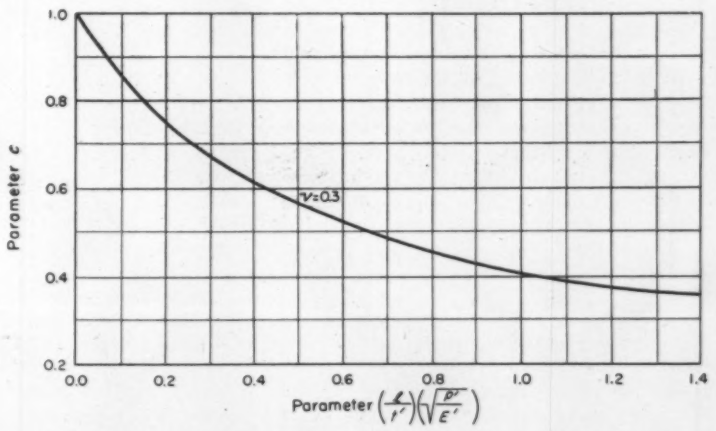


Fig. 6 — Analytical curve[7] for determining value of parameter c for adherend materials with Poisson's ratio, ν, of 0.3.

the solution of the two normal equations

$$\sum_j \log s_j - n \log a + b \sum_j \log x_j = 0$$

$$\sum_j (\log x_j \log s_j) - \log a \sum_j \log x_j + b \sum_j (\log x_j)^2 = 0$$

which give

$$b = - \frac{\sum_j (\log x_j \log s_j) - (\sum_j \log x_j)(\sum_j \log s_j)/n}{\sum_j (\log x_j)^2 - (\sum_j \log x_j)^2/n}$$

$$\log a = \frac{1}{n} \sum_j \log s_j + \frac{b}{n} \sum_j \log x_j$$

In the preceding equations, x_j and s_j are any pair of observed values of x and s and the summation is extended to all n values obtained in the test series.

Section 3

For U in Method C, Step 5.

The common intercept U with $l = 0$ of a family of q regression curves of s on l of the form $s_i = a_i l^2 + b_i l + U$ can be estimated by the method of least squares from the solution of the following system of $2q + 1$ equations

$$\sum_{j=1}^{m_i} (s_{ij} - a_i l_{ij}^2 - b_i l_{ij} - U) l_{ij}^2 = 0 \qquad (i = 1, 2, \ldots . q)$$

$$\sum_{j=1}^{m_i} (s_{ij} - a_i l_{ij}^2 - b_i l_{ij} - U) l_{ij} = 0 \qquad (i = 1, 2, \ldots . q)$$

$$\sum_{i=1}^{q} \sum_{j=1}^{m_i} (s_{ij} - a_i l_{ij}^2 - b_i l_{ij} - U) = 0$$

where l_{ij} and s_{ij} are any pair of observed values of l and s and the m summation is extended to the m_i values contributing to the i-th curve; the q summation covers all q curves.

Section 4

For $\sqrt{G/2E'}$ in Step 7 of Methods C and D.

The equation of a straight line passing through the origin of co-ordinates is $y = bx$. If both variables x and y are subject to error, the numerical value of b is estimated by

$$b = \frac{\sum_j y_j}{\sum_j x_j}$$

where x_j and y_j are any pair of observed values of $x = K_c$ or $x = K_d$ and $y = \sqrt{tt'}/l$ and the summation is extended to all values obtained in the test series.

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6. O. Volkersen—*Luftfahrtforchung*, Vol. 15, 1938.
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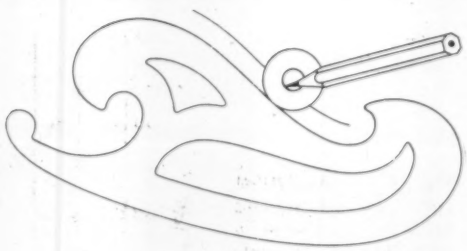
Tips and Techniques

Cleaning Tracings

Smudged, dirty tracings can be cleaned with masking or cellophane tape. To do this, wrap the tape, sticky side out, around the fingers of one hand to form a band about two inches wide. Remove from fingers, and holding by one thumb and finger tip, go over the soiled spots using short, light strokes, pulling toward you.—JOHN CAPKO, *Bendix Foundries, Teterboro, N. J.*

Drawing Parallel Curves

In many instances two or more parallel and irregular curves must be drawn. This may be done easily by holding the French curve on the original curve and then placing a washer against



the curve. The pencil point is inserted in the hole in the washer and the pencil then moved along to make the parallel curve. The washer maintains constant spacing between the edge of the French curve and the line. A collection of washers of differing diameters makes possible a series of such parallel curves.—JOHN A. SCHUM, *Rochester, N. Y.*

Design equations and charts for

Pressurized Cylinders and Spheres

By B. Saelman
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DESIGN of cylindrical and spherical pressure vessels is usually based on strength, deflection or energy requirements. In hydraulic cylinders, for example, diametral deflection often must be controlled because of clearances and functional requirements of hydraulic packings and seals.[1] Additional factors which may have an influence on the shape, size and weight of the pressure vessel structure are machinability limits, functional requirements, size and shape of raw stock, etc.

Pressure-loaded cylinders, Figs. 1 and 2, and spheres are generally divided into thick and thin-wall types. When the ratio of wall thickness to mean radius is less than 0.1, the design relationships for thin-wall, or membrane, structures are applicable. When the ratio exceeds 0.1, the formulas for thick wall cylinders should be used.

For thin-wall cylinders, a distinction is also made according to condition of loading: (1) longitudinal pressure loads not balanced externally, Fig. 2*a*; and (2) longitudinal pressure loads balanced externally, Fig. 2*b*. In the first case, hoop stress in the cylinder is twice the longitudinal stress. In the latter case, no longitudinal stresses are developed. For thick-wall cylinders, Fig. 1, the latter relationship is somewhat more complicated.

This article presents basic design equations for thick and thin-wall cylinders and spheres subject to external and internal pressure loads. In the analysis of cylinder structures, effect of both balanced and unbalanced load conditions on design relationships is considered. Stress and deflection equations presented in this discussion were taken from the literature.[2]

[1]References are tabulated at end of article.

▶Thick-Wall Cylinders—Internal Pressure

Where stress distribution stays within the elastic range, maximum hoop or circumferential stress at the inner surface of a thick-wall cylinder sub-

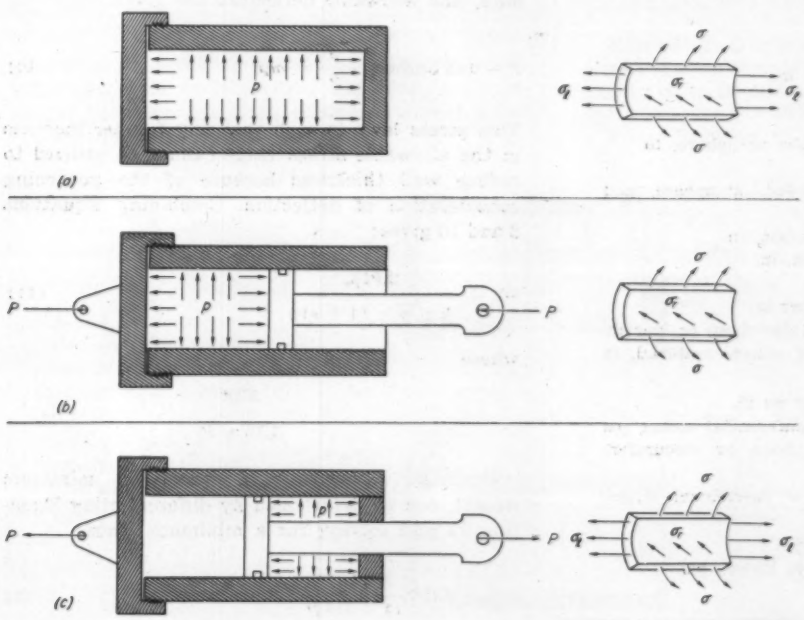

Fig. 1—Thick-wall cylinders under internal pressure load showing: *a*, pressure reservoir with externally unbalanced pressure loads; *b*, cylinder and piston with externally balanced pressure loads; and, *c*, cylinder and piston with externally unbalanced pressure loads. Stress distribution is triaxial at *a* and *c*, biaxial at *b*.

jected to internal pressure, Fig. 1, is given by:

$$\sigma = p\frac{R^2 + r^2}{R^2 - r^2} \tag{1}$$

where symbols are defined in Nomenclature.

When longitudinal stress σ_l is zero (externally balanced condition), Fig. 1*b*, the diametral deflection is:

$$\Delta d = 2\Delta r = \frac{d}{E}(\sigma + \nu p) \tag{2}$$

In terms of diametral strain, Equation 2 becomes,

$$\varepsilon_d = \frac{\Delta d}{d} = \frac{\sigma + \nu p}{E} \tag{3}$$

From Equation 3, letting $\sigma = F/n$ and solving for F,

$$F = n(\varepsilon_d E - \nu p) \tag{4}$$

where ε_d is specified.

Nomenclature

d = Inside diameter, in.
E = Young's modulus of elasticity, psi
E_h = Modulus of elasticity in hoop compression or tension, psi
F = Allowable stress, psi
l = Cylinder length, in.
N = Margin of safety
n = Burst pressure factor (frequently 2.5)
P = Applied external load, lb
p = Applied or operating pressure, psi
p_{max} = Maximum applied pressure, psi
R = Outside radius, in.
r = Inside radius, in.
t = Wall thickness, in.
V_c = Volume of cylinder, cu in.
V_s = Volume of sphere, cu in.
W = Weight, lb
W_c = Weight of cylinder tube or sphere, lb
W_f = Weight of fluid, lb
W_t = Total weight of cylinder, or sphere, and fluid, lb
Δd = Inside diametral deflection, in.
Δr = Inside radial deflection, in.
ν = Poisson's ratio
ε_d = Diametral strain, in. per in.
ε_l = Strain in longitudinal direction, in. per in.
ρ_c = Density of cylinder or sphere material, lb per cu in.
ρ_f = Density of fluid, lb per cu in.
σ = Applied hoop or circumferential stress, psi
σ_c = Applied compressive hoop or circumferential stress, psi
σ_l = Applied longitudinal or meridional stress, psi
σ_r = Applied radial stress, psi
σ_y = Hoop compressive yield stress, psi

Equation 4 gives the maximum practical stress level of the cylinder when radial or diametral deflection is the governing factor. From Equation 1, setting $R = r + t$ and $\sigma = F/n$,

$$t = r\left(\sqrt{\frac{F + pn}{F - pn}} - 1\right) \tag{5}$$

Equation 5 gives the required cylinder wall thickness based on stress. A similar expression for cylinder wall thickness based on deflection can be derived by combining Equations 4 and 5.

The weight of the cylinder tube can be expressed as:

$$W_c = \pi(R^2 - r^2)\rho_c l = \pi(2rt + t^2)\rho_c l \tag{6}$$

In the case of a hydraulic damper or liquid spring, Fig. 1*b*, when applied load P is specified,

$$P = \pi r^2 p \tag{7}$$

Combining Equations 5, 6 and 7 gives:

$$W_c = \frac{2Pn\rho_c l}{F - pn} \tag{8}$$

It is obvious that weight W_c is a minimum when pressure p is a minimum. By substitution of Equation 4 into Equation 8, an expression is derived for the weight of the cylinder tube when stress is determined by allowable deflection:

$$W_c = \frac{2P\rho_c l}{\varepsilon_d E - (1 + \nu)p} \tag{9}$$

Combining Equations 3, 4 and 7 provides an expression for determining the practical stress of the cylinder when the external load, internal pressure, and allowable deflection are given:

$$F = 0.89\,\Delta d E n\sqrt{\frac{p}{P}} - \nu n p \tag{10}$$

This stress level is such that any further increase in the allowable stress value cannot be utilized to reduce wall thickness because of the governing consideration of deflection. Combining Equations 8 and 10 gives:

$$W_c = \frac{2Pl\rho_c}{k\sqrt{p} - (1 + \nu)p} \tag{11}$$

where

$$k = \frac{E\Delta d}{1.13\sqrt{P}}$$

Optimum pressure p_{opt}, based on minimum weight, can be determined by differentiating Equation 11 and solving for a minimum. Thus,

$$p_{opt} = 0.196\frac{E^2(\Delta d)^2}{(1 + \nu)^2 P} \tag{12}$$

This equation establishes the design pressure for which the cylinder tube has minimum weight when the axial load and allowable diametral deflection are specified. A corresponding expression for optimum stress level can be developed by substituting Equation 12 into Equation 10.

Example 1: Determine design details for an optimum cylinder construction, based on minimum weight, in which pressure is to be applied internally. Given data are: Material is aluminum alloy; $E = 10^7$ psi; $\nu = 0.36$, $P = 100{,}000$ lb; $n = 2.5$; and $\Delta d = 0.008$-in.

From Equation 12, $p_{opt} = 6800$ psi; and from Equation 7, $r = 2.16$ in. Then, from Equation 10, assuming that the cylinder has a thick wall, allowable stress $F = 40{,}300$ psi. Required wall thickness of the cylinder is, from Equation 5, $t = 1.24$ in. Weight of this optimum design is, from Equation 6, $W_c = 6.88\pi\rho_c l$.

If an operating pressure of $p = 10{,}000$ psi is employed, $r = 1.78$ in. (Equation 7), $F = 47{,}000$ psi (Equation 10), $t = 1.44$ in. (Equation 5) and $W_c = 7.18\pi\rho_c l$ (Equation 6).

Similarly, if an operating pressure of $p = 4000$ psi is used, $r = 2.81$ in., $F = 31{,}700$ psi, $t = 1.07$ in. and $W_c = 7.19\pi\rho_c l$.

Total weight of the cylinder tube, accounting for the weight of the fluid, can be determined from the expression,

$$W_t = W_c + W_f = \pi(2rt + t^2)\rho_c l + \pi r^2 \rho_f l$$

$$= \frac{2Pn\rho_c l}{F - pn} + \frac{P\rho_f l}{p} \qquad (13)$$

Differentiating Equation 13 and solving for optimum pressure based on minimum weight gives the relationship,

$$p_{opt} = \frac{F(\sqrt{2\rho_c\rho_f} - \rho_f)}{n(2\rho_c - \rho_f)} \qquad (14)$$

Equation 14 establishes the pressure for which total weight of cylinder tube and fluid is a mintimum pressure based on minimum weight gives is allowed to vary.

Now, substituting the expression for P from Equation 7 into Equation 13, and solving for W_t yields:

$$W_t = V_c \frac{Bp + H}{\sigma - p} \qquad (15)$$

where $B = 2\rho_c - \rho_f$ and $H = \rho_f\sigma$. Equation 15 expresses the weight of a fluid-filled, thick-wall cylinder tube of fixed inside radius and under internal pressure loading, such as would be the case in the fluid lines of a hydraulic system. It is apparent that weight decreases with pressure as would be expected. This equation also indicates that the weight of a cylinder tube with fluid is fixed when volume and pressure are specified, as in a hydraulic accumulator. Since the size of end caps and piston heads reduces as cylinder diameter decreases, application characteristics of a long slender cylinder should also be considered in the interest of minimum weight.

Combining Equations 1, 5 and 7, it can be shown that

$$R^2 = \frac{P(F + np)}{\pi p(F - np)} \qquad (16)$$

Equation 16 provides the relationship between outside radius and internal pressure. When clearance is a problem in design, it is often necessary to determine minimum outside radius and at the same time satisfy functional and structural requirements. Differentiating Equation 16 with respect to p and solving for a minimum gives:

$$p_{R,\,min} = 0.414\frac{F}{n} \qquad (17)$$

where $p_{R,min}$ is the operating pressure for which outside radius R is a minimum.

Example 2: Determine internal operating pressure and dimensions of a cylinder in which outside radius is to be a minimum. Design data are: $P = 80{,}000$ lb; $F = 60{,}000$ psi; and $n = 2.5$.

From Equation 17, $p_{R,min} = 9860$ psi. Corre-

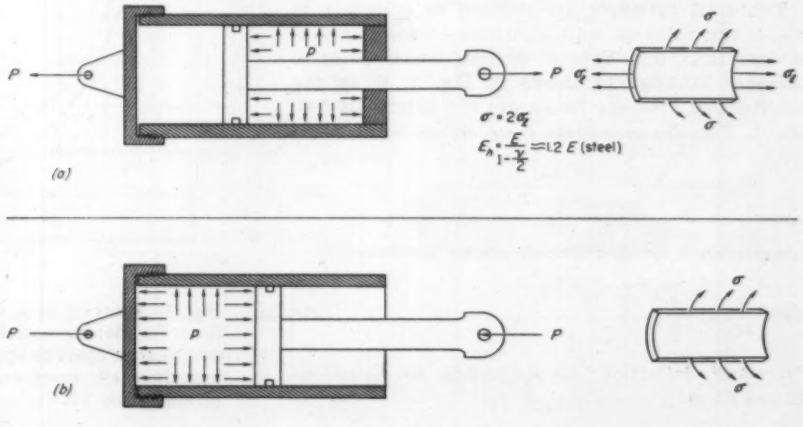

Fig. 2—Thin-wall cylinder and piston units under internal pressure load showing, *a*, externally unbalanced load condition and, *b*, externally balanced load condition.

sponding outside radius at this pressure is, from Equation 16, $R = 2.50$ in. From Equation 7, inside radius $r = 1.6$ in., and from Equation 5, $t = 0.9$ in. Note that $r + t = 2.50$ in. $= R$.

If $p = 5000$ psi, Equation 16 gives $R = 2.56$ in. Similarly, if $p = 14{,}000$ psi, $R = 2.63$ in.

For certain types of thick-wall cylinders, Figs. 1*a* and *c*, longitudinal pressure loads are not externally balanced. Maximum hoop stress for these designs is also given by Equation 1, however, internal diametral deflection now becomes:

$$\Delta d = 2\,p\,\frac{r}{E}\left[\frac{R^2 + r^2 - \nu(2\,r^2 - R^2)}{R^2 - r^2}\right] \qquad (18)$$

This equation is valid only for stress distribution within the elastic range. Similar design criteria can also be developed for this case as in the preceding analysis.

Thick-Wall Cylinders—External Pressure

For thick-wall cylinders under external pressure, or internal negative (suction) pressures,

$$\sigma_c = -\,2p\,\frac{R^2}{R^2 - r^2} \qquad (19)$$

where σ_c represents the maximum hoop or circumferential stress at the inner surface of the cylinder. Equation 19 is valid only for the elastic stress range.

Diametral deflection is given by:

$$\Delta d = 2\,\sigma_c\,\frac{r}{E} \qquad (20)$$

Solving for σ_c in Equation 20 gives:

$$\sigma_c = E\,\frac{\Delta d}{d} \qquad (21)$$

Equation 21 expresses the maximum practical stress in terms of allowable deflection.

Thin-Wall Cylinders—Internal Pressure

Thin-wall cylinders are defined as cylinders in which the ratio of wall thickness to mean radius is less than 0.1. Typical designs under internal pressure loading are shown in Fig. 2. When the longitudinal pressure forces are not externally balanced, Fig. 2*a*, maximum hoop stress is:

$$\sigma = \frac{pr}{t} \qquad (22)$$

Longitudinal, or meridional, stress becomes:

$$\sigma_l = \frac{pr}{2t} = \frac{\sigma}{2} \qquad (23)$$

Diametral deflection, corresponding to Equations 22 and 23, is:

$$\Delta d = \frac{\sigma d\left(1 - \frac{\nu}{2}\right)}{E} \approx \frac{\sigma d}{1.2E} \qquad (24)$$

Equation 24 can also be expressed as:

$$\Delta d = \frac{\sigma d}{E_h} \qquad (25)$$

where $E_h = 1.2\,E$.

From the basic definition for margin of safety,

$$F = n\sigma(1 + N) \qquad (26)$$

Combining Equations 24 and 26 gives the criterion for establishing maximum useable stress based on deflection:

$$F = nE_h(1 + N)\,\frac{\Delta d}{d} \qquad (27)$$

For thin-wall cylinders in which the internal pressure is externally balanced in the longitudinal direction, Fig. 2*b*, Equation 22 is still valid for determination of σ. But now $\sigma_l = 0$ and E replaces E_h in all relationships involving radial deflection.

For simplicity, a maximum diameter to thickness ratio,

$$\left(\frac{d}{t}\right)_{max} = K \qquad (28)$$

is sometimes used as a measure of the extent to which a tubular member may be machined. This limit seldom exceeds 50 and rarely approaches 60. Combining Equations 22 and 28 gives an expres-

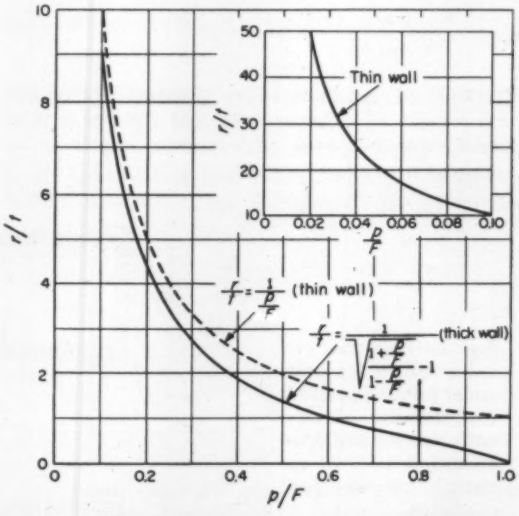

Fig. 3—Plots of basic thick and thin-wall equations for determination of cylinder wall thickness. Large chart is applicable for values of r/t less than 10; inset diagram for values of r/t greater than 10.

sion for practical stress based on the limit of machinability:

$$F = \frac{pKn}{2} \tag{29}$$

If the pressure forces resist an axial load, P, then, combining Equations 7, 13 and 22,

$$W_t = W_c + W_f = (2\,P\sigma + Pp)\,\frac{\rho_c l}{\sigma^2} + \frac{P}{p}\,\rho_f l \tag{30}$$

The pressure for minimum cylinder weight can be found by differentiation of Equation 30:

$$p_{opt} = \sigma \sqrt{\frac{\rho_f}{\rho_c}} \tag{31}$$

If the weight of fluid is ignored, it is apparent from Equation 30 that the weight of the cylinder decreases as p decreases. Also, it can be shown that

$$W_t = \frac{2\,V_c p}{\sigma}\,\rho_c + V_c \rho_f \tag{32}$$

This equation indicates the variation of weight with pressure for a fixed cylinder volume.

In wall thickness calculations, Equation 5 for thick-wall cylinders will always give larger values than Equation 22 for thin-wall structures. However, Equation 22 provides a safe value of t and is recommended whenever $t/r < 0.1$. Plots of r/t versus p/F for both thick and thin-wall cylinders are given in Fig. 3. If p, F, and r are known, t can quickly be determined by this plot. Figs. 4*a* and *b* illustrate the difference in values of wall thickness as determined by Equations 5 and 22 for two special cases.

Example 3: Determine correct wall thickness for a cylinder where $P = 100{,}000$ lb, $F = 180{,}000$ psi, $p = 4000$ psi, and $n = 2.5$. From Equation 7, $r = 1.77$ in. From Equation 5 (thick-wall cylinders), $t = 0.106$-in., and from Equation 22 (thin-wall cylinders), $t = 0.098$-in. For the latter value, ratio of thickness to mean radius is $0.098/(1.77 + 0.049)$, which is less than 0.1. Thus, $t = 0.098$-in. will be used.

Example 4: A thin-wall steel cylinder in which the longitudinal tension is zero, Fig. 2*b*, has a bore of 3-in. Determine the maximum practical strength and corresponding thickness of the cylinder wall when allowable diametral strain, $\epsilon_d = 0.002$-in. per in., $p = 3000$ psi and $E = 29 \times 10^6$ psi.

Combining Equations 22 and 25 and replacing E_h with E gives:

$$t = \frac{pd}{2E\,\dfrac{\Delta d}{d}} = \frac{3000(3)}{2(29)(10^6)(0.002)} = 0.078 \text{ in.}$$

From Equation 27 for a margin of safety, $N = 0$, maximum practical strength $F = 145{,}000$ psi. For unbalanced load conditions, Fig. 2*a*, note that $E_h = 1.2E$ and $F = 174{,}000$ psi.

▶Thin-Wall Cylinders—External Pressure

Collapsing pressure p_{col} of a thin wall cylinder for nonelastic failure is given by:

$$p_{col} = \frac{t}{r}\left[\frac{\sigma_y}{1 + \dfrac{4\sigma_y}{E}\left(\dfrac{r}{t}\right)^2}\right] \tag{33}$$

Maximum stress of the cylinder tube as limited by deflection can be determined from Equation 27, using compressive stress and modulus of elasticity in compression as a basis for solution. If p and r are given, required wall thickness can be solved from Equation 33. Compressive hoop stress is given by the equivalent form of Equation 22 for compression loading,

$$\sigma_c = p_{col}\,\frac{r}{t} \tag{34}$$

If only p is specified, Equations 27, 33 and 34 can be used in combination to determine r and t so that the stress corresponding to collapsing pres-

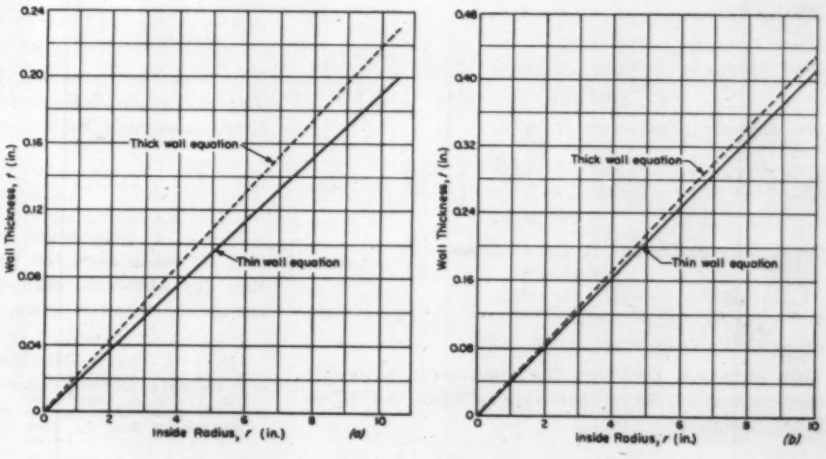

Fig. 4 — Comparison of cylinder wall thickness values given by thick and thin-wall equations for two special design cases. At *a*, $F = 50{,}000$ lb and $p = 10{,}000$ psi; at *b*, $F = 180{,}000$ lb and $p = 7500$ psi. Equation 5 is basic expression for thick-wall cylinders, Equation 22 for thin-wall structures.

sure equals the stress limited by deflection.

Thick-Wall Spheres—Internal Pressure

Maximum hoop stress in a thick-wall sphere under internal-pressure loading is given, for the elastic range, by:

$$\sigma = p\frac{(r+t)^3 + 2r^3}{2[(r+t)^3 - r^3]} \tag{35}$$

Diametral deflection is:

$$\Delta d = \frac{2pr}{E}\left[\frac{R^3 + 2r^3}{2(R^3 - r^3)}(1-\nu) + \nu\right] \tag{36}$$

Combining Equations 35 and 36 gives:

$$\sigma = \frac{F}{n} = \frac{1}{1-\nu}\left(\frac{\Delta d}{d}E - \nu p\right) \tag{37}$$

Equation 37 provides the maximum practical stress of the sphere as determined by allowable diametral deflection. From Equation 35,

$$t = r\left[\sqrt[3]{\frac{2(\sigma+p)}{2\sigma - p}} - 1\right] \tag{38}$$

Weight of the sphere can be expressed,

$$W_c = \frac{4\pi\rho_c}{3}[(r+t)^3 - r^3] \tag{39}$$

Combining Equations 38 and 39 gives:

$$W_c = \rho_c V_s \frac{3p}{2\sigma - p} \tag{40}$$

where volume $V = (4\pi r^3)/3$. It is seen that W_c is a minimum when p is a minimum.

Thick-Wall Spheres—External Pressure

Maximum compressive hoop stress for a thick-wall sphere under external pressure can be determined from

$$\sigma_c = -p\frac{3R^3}{2(R^3 - r^3)} \tag{41}$$

and diametral deflection from

$$\Delta d = -\frac{2pr}{E}\left[\frac{3R^3}{2(R^3 - r^3)}(1-\nu)\right] \tag{42}$$

Combining Equations 41 and 42 gives:

$$\sigma_s = \frac{\Delta d E}{d(1-\nu)} \tag{43}$$

This equation provides the maximum allowable compressive stress of the sphere when deflection is the design criterion.

Thin-Wall Spheres—Internal Pressure

For the thin-wall sphere under internal pressure loading,

$$\sigma = \frac{pr}{2t} \tag{44}$$

$$\Delta d = \frac{d\sigma}{E}(1-\nu) \tag{45}$$

Solving Equation 45 for σ gives the maximum practical stress of the sphere based on allowable deflection. From this relationship it is apparent that

$$E_h = \frac{E}{1-\nu}$$

Weight of the sphere and fluid is:

$$W_t = 4\pi r^2 t\rho_c + \frac{4}{3}\pi r^3\rho_f \tag{46}$$

Combining Equations 44 and 46 gives:

$$W_t = \frac{3}{4}V_s\left(\frac{2\rho_c p}{\sigma} + \frac{4\rho_f}{3}\right) \tag{47}$$

Thus, W_t is a minimum when p is a minimum.

Thin-Wall Spheres—External Pressure

Maximum compressive hoop stress and diametral deflection are:

$$\sigma_c = -\frac{pr}{2t} \tag{48}$$

$$\Delta d = -\frac{2r\sigma_c}{E}(1-\nu) \tag{49}$$

Solving for σ_c in Equation 49 gives the maximum practical compressive stress of the sphere. If elastic instability of the sphere is critical,[2] the critical pressure, p_{cr}, is:

$$p_{cr} = \frac{2Et^2}{r^2\sqrt{3(1-\nu^2)}} \tag{50}$$

Combining Equations 48 and 49 and solving for p gives:

$$p = \frac{t\,\Delta d\,E}{r^2(1-\nu)} \tag{51}$$

This equation provides the maximum allowable pressure when deflection is the design criterion. Now, combining Equations 50 and 51 gives:

$$t = \frac{r\sigma_c}{E}\sqrt{3(1-\nu^2)} \tag{52}$$

where σ_c is determined from Equation 49. Equation 52 establishes the required wall thickness so that the allowable deflection is not exceeded and instability does not occur.

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2. R. J. Roark—*Formulas for Stress and Strain*, 2nd Edition, McGraw-Hill Book Co., New York, 1943.

Types and characteristics of

Bearing Seals

By J. M. Bryant
Chief Engineer
Dodge Plant
Link-Belt Co.
Indianapolis, Ind.

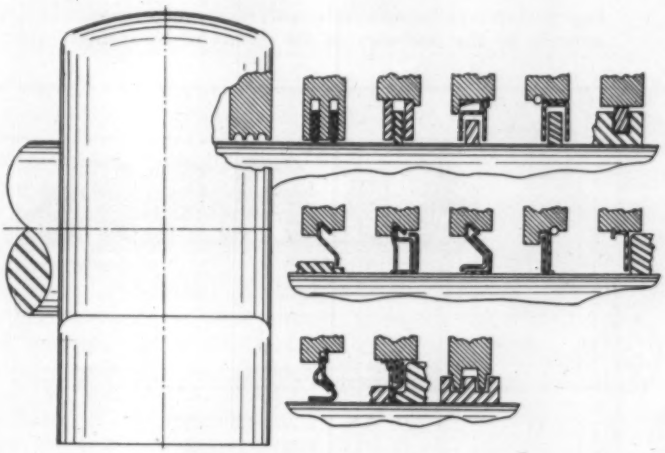


Fig. 1—Typical clearance seals.

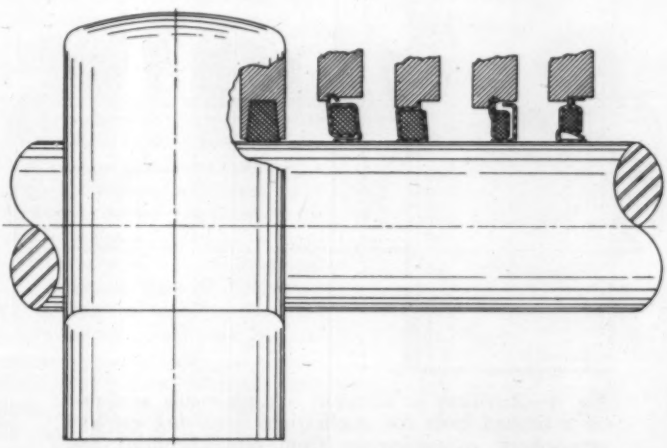


Fig. 2—Contact seals using wool and/or Dacron felt.

CONVENTIONAL antifriction bearing pillow blocks and other forms of bearing blocks, such as the flange and take-up types, are regularly manufactured with seals as illustrated in Figs. 1 through 4.

Enclosed gear drives are regularly made with shaft seals as illustrated in Fig. 5. The various clearance and contact seals follow about the same general pattern as those for bearing blocks, lacking only in variety. Fig. 6 illustrates the axial type of contact seal usually used when oil levels are above the shaft opening.

Ingress problems may involve chemical or moisture-laden atmosphere, solids (abrasive and/or absorptive), and liquids. Ambient temperature and volume of air within a housing will influence ingress, and temperatures above 200 F may act to deteriorate various contact sealing media.

Egress problems, on the other hand, may involve retention of oil or grease, the operating temperature range of the bearing, and acceptable limit of egress if any is to be allowed.

Seal Characteristics: Characteristics of the various seal types, with due consideration of certain engineering fundamentals, are compared in Table 1.

CLEARANCE SEALS (labyrinth type) as presently marketed, generally will be adequate for all applications, with the following possible exceptions:

1. Chemical and/or moisture-laden atmosphere coupled with vari-

able temperatures in the bearing or drive.
2. Chemical and/or moisture-laden atmosphere, coupled with a rapid movement of air over the bearing or drive.
3. Where the slightest egress of lubricant would seriously mar a product or cause serious contamination.
4. Any dust - laden atmosphere where the temperature range or frequency of change of temperature of drive or bearing may be sufficient to cause considerable breathing through the seals.
5. Water dropping or flooding over a bearing or drive.
6. Where there is a direct spill of material on the housing.
7. Where supports for a bearing or gear drive are designed in a manner that will allow an accumulation of material to partially or completely bury the bearing or drive.
8. Oil lubrication in the presence of rapid air movement over the housing.

CONTACT SEALS as presently marketed in stock bearings and drive units will be adequate, within the speed limits recommended, for all applications except:

1. Where supports for a bearing or gear drive are designed in a manner that will allow an accumulation of material to partially or completely bury the bearing or drive.
2. Chemical and/or moisture-laden atmosphere coupled with variable temperatures in the bearing or drive.
3. Water dropping or flooding over a bearing or drive or in chemical-laden atmosphere.
4. Temperatures in excess of 200 F at the sealing surface.
5. Where extreme-pressure (EP) lubricants may be a mechanical requirement of the gears and bearings. (It should be determined if the EP property will have an adverse effect on the seal.)
6. Where seal torque would affect the operation of the equipment on which the bearing is used.

Accessory Sealing: The foregoing exceptions may in most cases be partially or completely offset by the use of accessory sealing means. This will involve higher cost and procurement delay but will insure

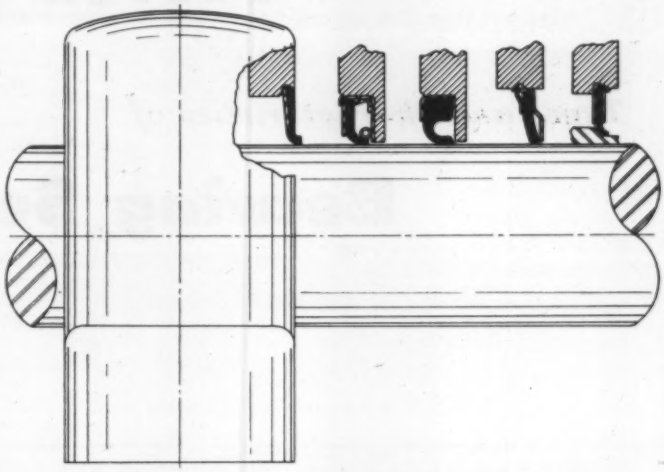


Fig. 3—Lip type contact seals made of synthetic rubber, actuated by the resiliency of the rubber or by springs.

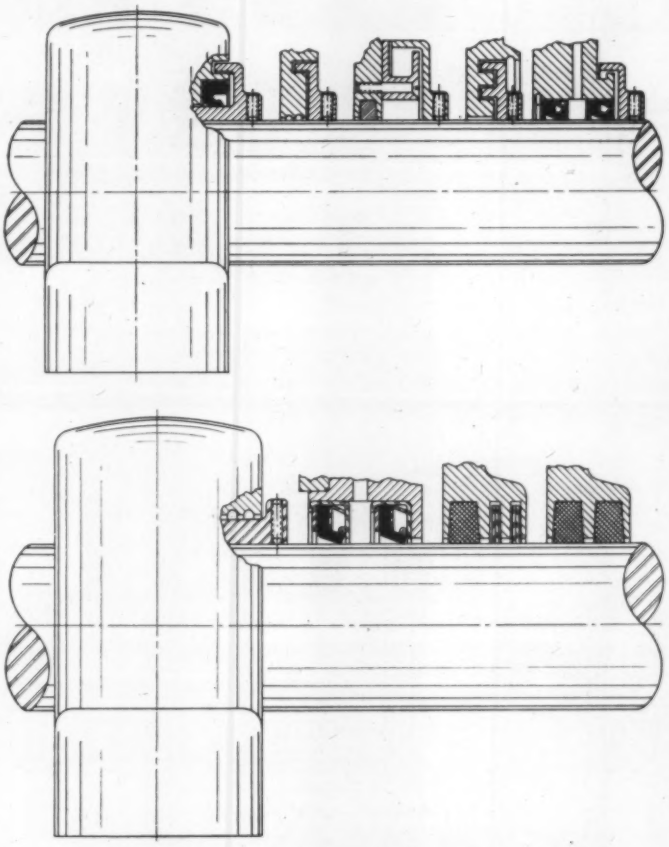


Fig. 4—Auxiliary or accessory sealing media available on a limited basis for applications involving extreme atmospheric contamination from dirt, chemicals and moisture.

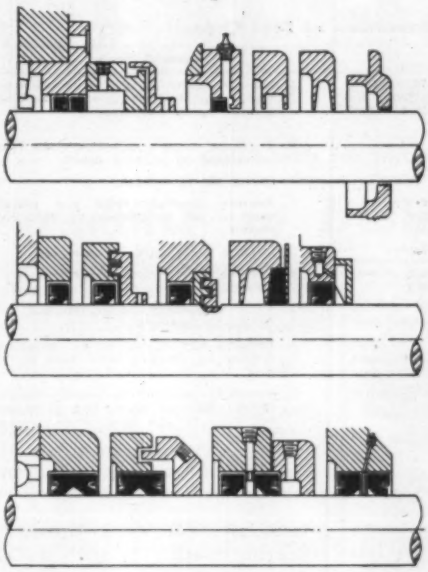


Fig. 5 — Seals and auxiliary sealing used on drive housings.

longer trouble-free performance. The following discussion covers a few of the possibilities for accessory sealing media:

1. Wherever possible, potential spill points should be kept away from bearings and drives. Where this is impossible, the supports should be designed to avoid accumulation of dirt around sealing points, or deflector plates should be used to divert spill.

2. A second contact seal forming a dual arrangement, with space between the seals for grease, is recommended where spill of dirt and buried conditions cannot be avoided by suitable deflectors and proper design of supports.

3. Clearance or labyrinth seals added to original contact seal or to a dual seal arrangement as described in the previous paragraph may be recommended where spill or dirt and buried conditons cannot be avoided by suitable deflectors and proper design of supports.

4. A rotating type of flinger or baffle in addition to a regular contact or clearance seal may be recommended where there is a continuous flow of water over the housing. This type of flinger or baffle may be of help in shielding against falling dirt. However, the effectiveness of this accessory would vary with speed, specific gravity, and nature of the material. It would have no value if partially or completely submerged in material.

5. Grease is a possible aid to sealing. A good grade of grease may be used in labyrinth seals and between dual seals. Means may be provided to flush the seals with grease through the bearing grease fitting or by a separate fitting. Flushing through the bearing fit-

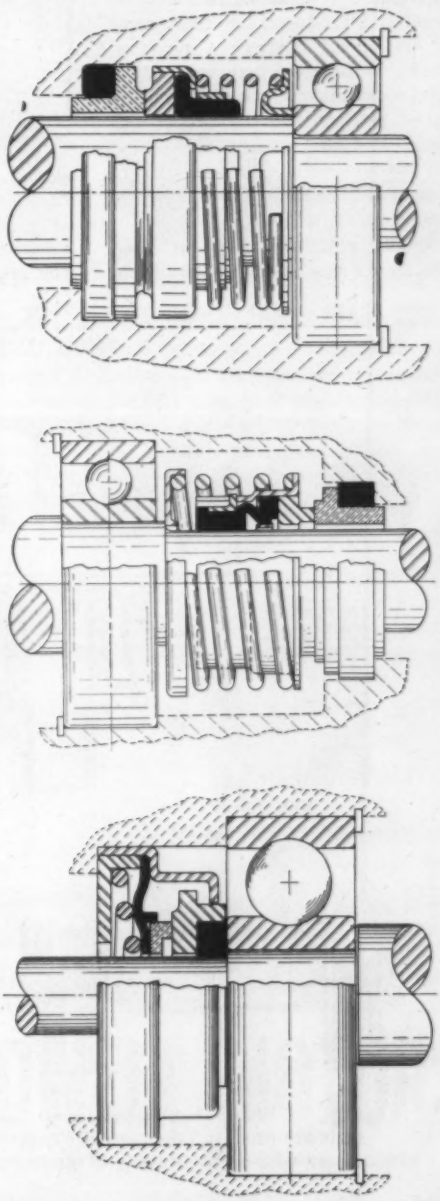


Fig. 6 — Axial seals usually used when oil levels are above the shaft opening.

ting would not be practical at high speeds, because there would be excessive churning and egress of grease during operation. Seal flushing is regularly used on gear drive seals to wash the outside face of contact seals, even though the bearing and gear drive are oil lubricated. Experiments have indicated that flushing seals through the bearing may cause more harm than good. It depends on how careful the mechanic is in wiping dirt from the grease fitting and gun connection. A small amount of abrasive introduced in this manner will soon destroy a bearing. Where applications are very dirty it is recommended that the bearing be greased for the life of the grease and that grease be applied only to the seals, the seal design being such that it will pass the grease outward only.

Grease will not stop oil flow. This limits the use of a labyrinth-sealed bearing block, grease-lubricated, which is fastened on the side of a drive box. The drive, oil-lubricated, soon splashes oil against the labyrinth seal, and in a short time oil will work through the bearing block. In such instances, flinger baffles or spring-loaded lip seals may be used. Flinger baffles adapted to the drive housing would likely permit use of standard bearing blocks with labyrinth seals.

Table 1—Comparison of Seal Characteristics

Clearance Seals	Contact Seals
1. Simplest means of blocking mechanical damage to bearings or gears, and protection against large particles.	1. More complicated design considerations, but provide good protection against small particles.
2. Frictionless in operation.	2. Frictional drag and temperature rise influenced by surface speed.
3. Free air passage through seal.	3. Resist air movement.
4. Operation unimpaired by minor imperfections in shaft surface.	4. Require freedom from any spiral marking or roughness of rotating portion.
5. Require less care in assembly.	5. Require more care in assembly.
6. More sensitive to rapid air movement over outside of housing.	6. Less sensitive to air movement over housing.
7. Less protection under direct spill of material or under buried conditions.	7. More protection under spilling or burial in material.
8. Allow flushing of bearings with fresh grease through seals without building up pressure.	8. Require use of pressure- relieving devices for flushing with fresh lubricant.
9. Usually not affected by temperature.	9. Generally, deteriorate rapidly above 200 F. Silicone rubber will do better but may not be used with silicone fluids.

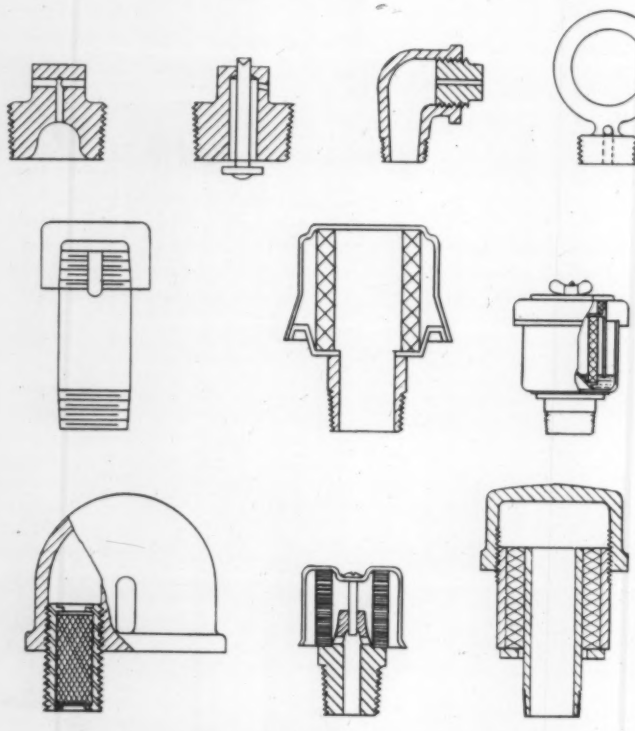


Fig. 7—Breathers applicable on units where contact seals are used, to take care of expansion and contraction of air within the bearing or drive housing.

6. Breathers with filters are applicable on all units where contact seals are used, to take care of the expansion and contraction of air within the bearing or drive as the stationary and operating temperature varies, Fig. 7. This avoids egress of lubricant and ingress of dirt at the seals, confining air movement to the breather that filters the air. Where atmosphere around the bearing or drive is clean, the filter may be omitted. Breathers are also used with clearance seals to equalize air pressures which originate from a stream of air passing over the housing.

7. Where moisture, water, or chemical-laden atmosphere can reach the rotating seal member adjacent to the line of seal contact, rusting may occur, which will destroy the seal. Auxiliary flingers beyond the primary seal may suffice for moisture conditions, but in a chemical-laden atmosphere it may be desirable to use stainless steel or some other material resistant to corrosion for the sealing surface.

8. Dry well seals and spring-loaded axial contact seals may be grouped under accessory sealing because of their use in worm drives (in particular) to meet the

HOWELL MOTOR BRIEFS

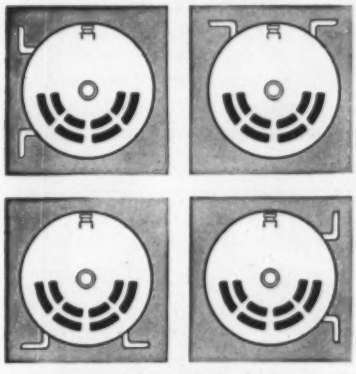
Quick facts for those who apply and specify electric motors

Flexibility of Design Aids Motor Applications

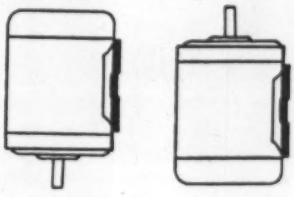
When they originally embarked upon the program of developing the basic Series 100 motor design for the new rerated frame sizes, Howell engineers set goals considerably above and beyond the requirements of the NEMA specifications. Among them, "maximum flexibility" of design was achieved to a degree that is outstanding in the motor industry . . . and that directly benefits machine designers who utilize standard motors.

Involved is not only unusual flexibility of positioning and lead connections, but a ready interchangeability of the five basic enclosure types within each frame size.

DESIGNED FOR MOUNTING IN ANY OF SIX POSITIONS

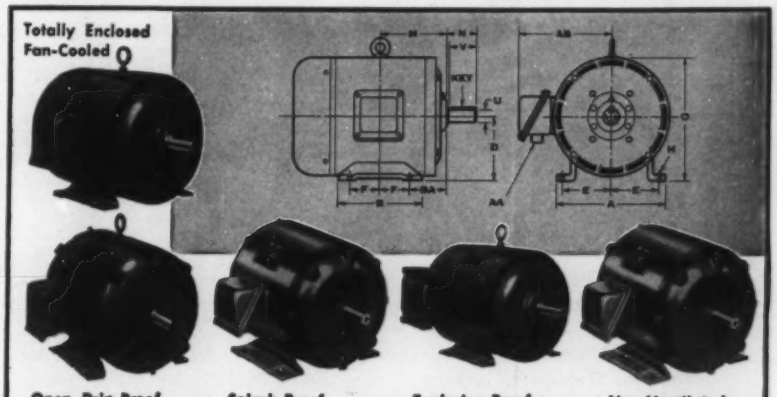


As illustrated by the diagrams above, Howell Series 100 Open Drip-Proof motors can be side-wall or ceiling mounted simply by revolving the end plates. The other four basic enclosure types do not even require this simple change.

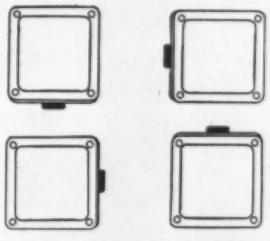


SHAFT DOWN SHAFT UP

Series 100 Totally Enclosed Fan-Cooled motors — in fact all of the five enclosure types — can also be mounted shaft down or shaft up with no modification in design required.

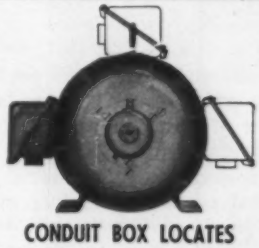


FIVE BASIC SERIES 100 ENCLOSURES HAVE SAME DIAMETERS, SHAFT AND MOUNTING DIMENSIONS — Unlike many other motors, the basic Howell Series 100 enclosures do not vary in diameter (or any of the essential mounting dimensions, except length) from one type to another (except a few 2-pole ratings). This is because of the way Howell accomplishes motor cooling, with "heat source" ventilation ducts in the stator itself . . . not by enlarging Totally Enclosed Fan-Cooled or Explosion-Proof frame diameters. This uniformity simplifies space allocations for the machine designer and allows for interchangeability of enclosure types to meet varying job requirements.



BOX EASILY ROTATED FOR 4-WAY HUB LOCATION

Series 100 conduit boxes are mounted to the frames with 4 screws, accessible for easy rotation of the box so that the integral, threaded nipple takes conduit from any of four directions.



CONDUIT BOX LOCATES TO FIT ANY REQUIREMENTS

For further flexibility, a simple modification can be specified for positioning of the conduit box in any of three positions around Series 100 frames.

GET COMPLETE DETAILS WRITE FOR BULLETIN N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

Circle 468 on page 19

egress problems when the worm is below the worm wheel and the oil level is above the shaft seal; also when the worm wheel shaft (low speed) is projecting downward and the shaft seal is below the oil level.

From a paper entitled "Sealing, Drives and Anti-Friction Bearings" presented before the Philadelphia Section, American Society of Lubrication Engineers, January, 1957.

Design characteristics of

Sealed Electrical Terminals

By R. F. Squires

Component Development
Bell Telephone Laboratories Inc.
New York

SEVERAL factors must be considered in the design of a sealed terminal for a given application:

1. Breakdown, flash-over, and corona-starting voltages under specific conditions of temperature, humidity and atmospheric pressure.
2. Insulation resistance under the same conditions, with or without a dc polarizing voltage.
3. Current-carrying capacity.
4. Reliability of the seal.
5. Ability to withstand mechanical and thermal shock.
6. Space requirements.
7. Unit and installation costs.

Increasingly widespread use of sealed terminals and their varied physical and electrical requirements have resulted in a large number of terminal types for specific purposes. Fig. 1 shows several components using a variety of terminal types and sealing materials.

Rubber Seal: The first practical, low-cost sealed terminal developed by Bell Telephone Laboratories was the rubber-sealed terminal, Fig. 2. Natural rubber is used in the shorter assemblies, and their use is restricted to units not impregnated with oil or oily compounds.

Molded Phenolic Seal: Although their characteristics are generally very good, rubber-sealed terminals have been limited to applications where test voltages do not exceed about 6000 v dc or operating voltages do not exceed about 3000 dc. Chlorinated impregnants used in capacitors to achieve higher capacitances for the same unit volume are harmful to rubber; molded phenolic terminals, Fig. 3, were designed for such applications. Phenolic material is molded between and around a metal lead-through and a concentric metal bushing; these parts are shaped for mechanical strength and a good seal. These terminals are used at voltages up to 10,000 dc at room temperature and up to 5000 dc at 185 F.

Metal - Glass Terminals: The trend toward miniaturization of components and the demands of the military during and after World War II led to further improvements in previously developed metal-glass terminals. Outside industry had developed glass-sealed terminals using a metal lead-through and bushing, separated by glass fused to the metal parts. The Laboratories undertook the design and development of smaller terminals using this process and the same materials—a special alloy, Kovar, and borosilicate glass. Several of these metal-glass terminal designs, some of which are shown in Fig. 4, are used in substantial quantities. They are somewhat restricted in their applications because electrodeposition of metal over the glass

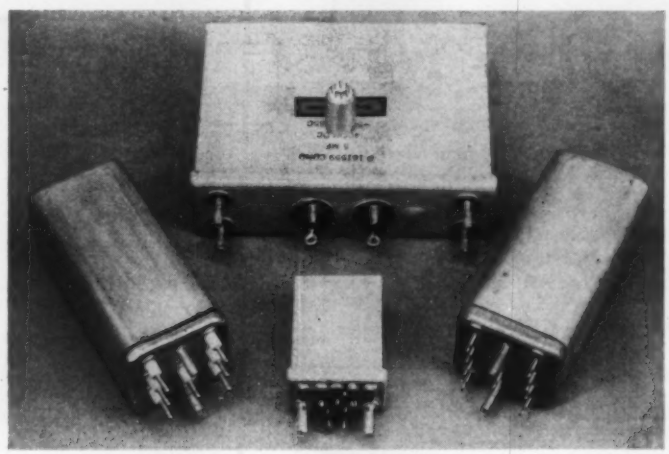


Fig. 1—Component cans using various types of sealed terminals. Sealing materials are: left, solder-sealed ceramic; center foreground, rubber; center top, molded phenolic; right, glass. The small tubular can resting on the large unit, center, has cold-compression fluorocarbon resin-sealed terminals.

So Many Products from These Husky Steel Blanks

If some of your products require the use of circular steel parts, then Bethlehem's forged-and-rolled blanks should be of unusual interest to you. For Bethlehem makes blanks by a method that forges and rolls the steel in a single operation, thus insuring uniform density, excellent grain flow, and very high strength. It is a process unduplicated by any other manufacturer.

For many years customers have used these strong steel blanks in making gears, crane wheels, end rings, sheave wheels, turbine rotors, flywheels, tire molds and rings, pistons, clutch drums, and similar parts. Because of the high strength inherent in the blanks, it is often feasible to employ thinner-than-usual sections. This means a saving in weight. And machining can be done so dependably that there is almost never a reject.

Bethlehem blanks come in a wide range of sizes—approximately 10 to 46 in. OD. They can be furnished heat-treated or untreated. And they are competitive pricewise, so that you can use them without increasing your costs.

Full details will be furnished by the Bethlehem office nearest you. Write for complete information.

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surface, when subjected to repeated temperature-humidity cycles with dc polarizing voltage across the terminal, results in the lowering of insulation resistance, as indicated in Table 1.

Fluorocarbon Resin: Further miniaturization of some components created a demand for sealed terminals that would meet more stringent requirements. Two designs using fluorocarbon resins were evolved at the Laboratories, Fig. 5. One design consists of a fabricated wire lead-through and a concentric flanged metal bushing, separated and held in position by a fluorocarbon resin carefully molded to avoid internal air pockets that would affect the electrical characteristics of the terminal. These terminals use a resin (polychlorotrifluoroethylene) that can withstand fairly high temperatures and has particularly useful properties for miniaturized military equipment. Considerable care must be exercised in the fabrication and installation of these terminals to retain the desirable properties.

Usually, apparatus units are impregnated and filled with a potting compound after all soldering operations have been performed, including those on the terminals. Temperatures involved during impregnation are sometimes sufficiently high to jeopardize some types of terminal seals, thus restricting the choice of seal materials. A second type of fluorocarbon resin terminal can be made directly on the apparatus at room temperature after impregnation and potting have been done, eliminating this problem. In this process, a fairly heavy-walled bushing is fastened to the can cover or is formed as part of the can cover. The space between the bushing and a central wire lead-through acts as a filler hole for the drying, impregnating, and potting operations, and is then sealed with resin. A sleeve of either polychlorotrifluoroethylene or another plastic (polytetrafluoroethylene) is slipped over the lead-through into the bushing and is then compressed with a suitable tool. This gives a hermetic seal between sleeve and

Fig. 2—Large and small rubber-sealed terminals.

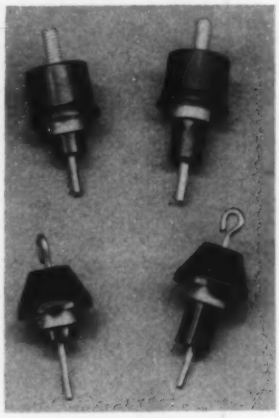


Fig. 3—Short-shank, left, and long-shank molded phenolic terminals.

Fig. 4—Copper-glass, center, and glass-sealed terminals.

P&B STRIKE SETTLED!

AN OPEN LETTER TO RELAY USERS

Potter & Brumfield, inc.

Dear Friends:

Ruthless violence, culminating on February 13 with the shooting of the four-months-old baby daughter of two of our employees, focused national attention on a recent strike at our Princeton, Indiana plant.

This unjustified strike was called on November 5, 1956 in the face of our "no strike" contract with Local 1459 of the International Association of Machinists. No demands or proposals for settling the strike were made by the Union. Two Company proposals were summarily rejected.

Settlement of the strike was reached on February 28, 1957.

Our plants in Laconia, New Hampshire and Franklin, Kentucky were not affected by the strike.

Production lines were shifted from Princeton to both Laconia and Franklin plants, and employment has been greatly increased at both locations. These plans were made before the work stoppage to increase production.

Production at Princeton was resumed on December 17th, and today a normal work force is manning the remaining lines. Until recently, the training of new workers restricted our productivity, but output now is at satisfactory levels.

With three plants to serve you, we pledge our continued efforts to provide you with relays of the finest quality. Our Engineering Department welcomes the opportunity to work with you on new designs and future projects.

Sincerely,

Dale V. Cropsey

Dale V. Cropsey
Vice President & Director of Sales

NOW!
3 PLANTS TO SERVE YOU

POTTER & BRUMFIELD, INC. PRINCETON, INDIANA
A Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY

bushing and between sleeve and lead-through.

Gasket-Sealed Ceramic: When still higher voltages are encountered, ceramic terminals are used. In compression - type ceramic terminals, Fig. 6, the insulator body consists of two parts, one inside and one outside the can, and a central lead-through threaded on one end to provide axial compression. Sealing is provided by special gaskets wherever the ceramic comes in contact with a metal surface. Two features are of interest: The hollow body permits the insulating oil of a unit to fill the insulator and improve the electrical characteristics, and a terminal may be constructed with either a single or two coaxial lead-throughs.

Solder-Sealed Ceramic: Solder-sealed ceramic terminals fall into two classes, differing primarily in the glazed ceramic material of the bodies and the method of attaching the metal parts or "hardware" to the ceramic. One class uses steatite-type ceramic with specific areas of the bodies coated with metals; a paste of colloidal silver is fired onto the ceramic, and copper and then tin are electroplated onto the silver for better solderability. Soft (lead-tin) solder is used to attach the hardware as well as for mounting the terminal onto the apparatus can.

The other class, the so-called "high alumina" terminals, Fig. 7, are a more recent development. The ceramic material, chiefly recrystallized aluminum oxide, is more resistant to thermal shock and can withstand higher temperatures. Because of this, it is possible to apply a higher-temperature glaze that has superior nonwetting properties and surface resistivity. Such terminals retain their high insulation resistance under extreme conditions of humidity and voltage. Also, by using special metallizing techniques, the hardware is attached to the ceramic with high-temperature brazing alloys. These terminals have superior electrical and mechanical properties and are

Fig. 5—Molded plastic, left, and cold-compression fluorocarbon resin-sealed terminals.

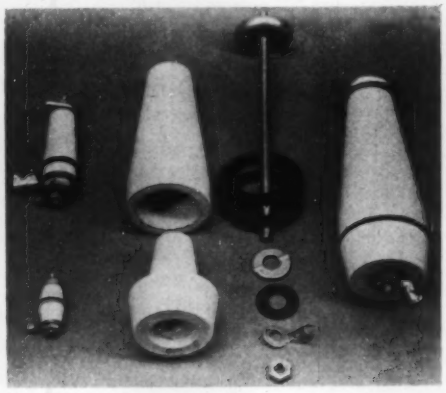
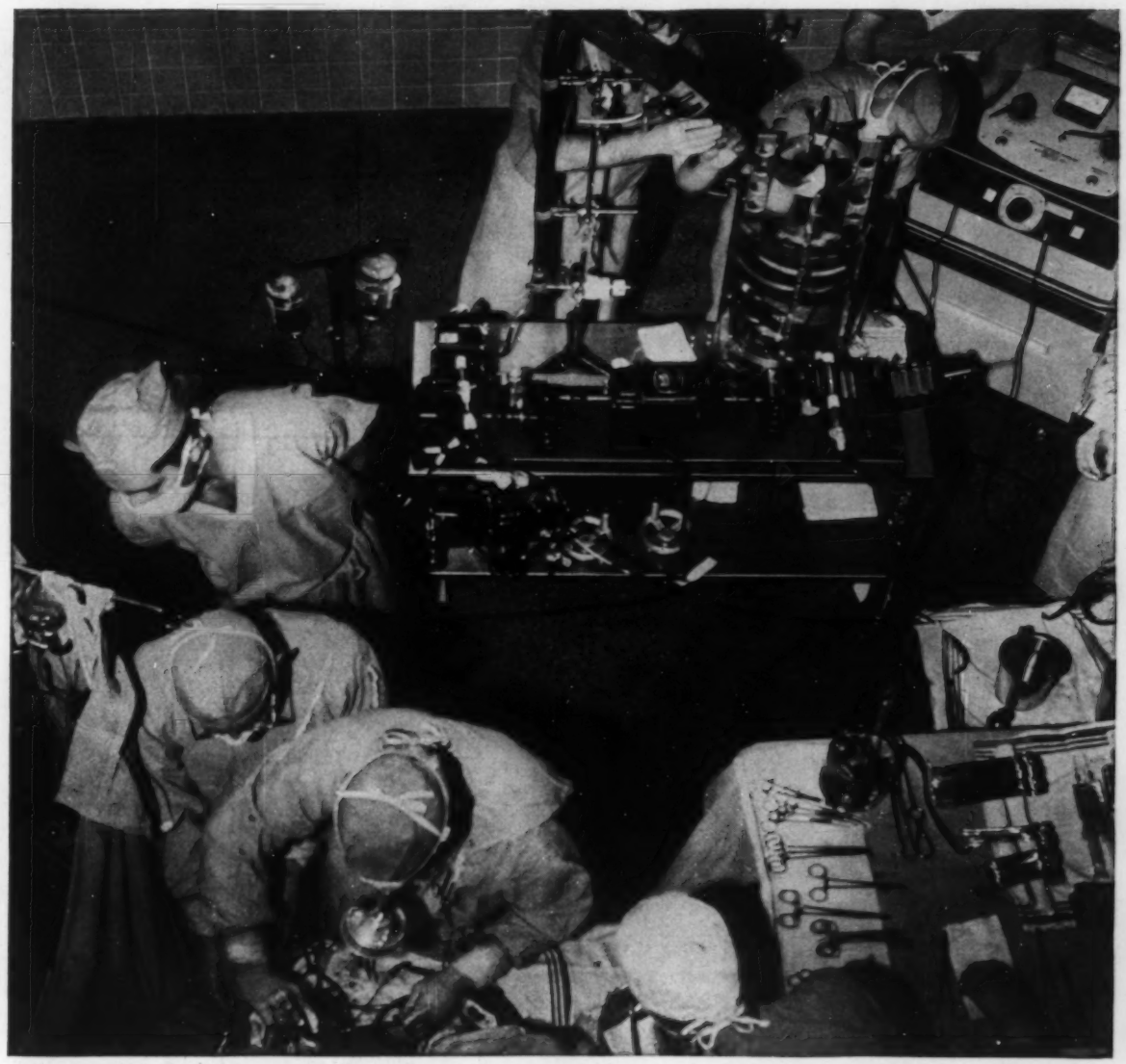


Fig. 6—Three sizes of gasket-sealed ceramic terminals with a large terminal disassembled. The terminal at upper left contains two coaxial feed-throughs.

Table 1—Typical Electrical Characteristics of Terminals

Terminal	—Peak Voltages at Room Conditions (kv)— Maximum Test	Working	Corona-Starting	Insulation Resistance (megohms) As Assembled	After Moisture Resistance Test with Polarizing Voltage	Current Rating (amp)
Rubber-Sealed						
Smallest size	2.4	0.6	1.2	over 10^5	over 10^5	5
Longest sleeve	6	3	3	over 10^5	over 10^5	5
Molded Phenolic						
Short shank	5	2	1.2	over 10^4	over 10^3	10
Long shank	10	5	1.2	over 10^4	over 10^3	10
Metal-Glass						
Smallest size	2.1	0.5	1.4	over 10^5	under 1	5.5
Largest size	5.6	1.4	3.7	over 10^5	under 1	21.5
Fluorocarbon Resin (2 types)						
Compressed	6.5	2.5	3.7	over 10^5	over 10^5	5
Molded	7	2.8	2.8	over 10^6	over 10^6	15
Gasket-Sealed Ceramic						
Smallest size	5.6	2.1	4.2	over 10^5	over 10^4	15
Largest size	100	50	60	over 10^5	over 10^4	15
Solder-Sealed Ceramic						
Smallest size	5	1.5	1.3	over 10^5	over 10^4	3
Largest size	35	17	21	over 10^5	over 10^3	30



Leland Motors circulate blood for "stopped heart" surgery

Combining their knowledge and skills the University of Minnesota and Sigmamotor, Inc., have perfected an ingenious heart-lung machine which permits a surgeon to stop a beating heart, open it and then work inside for extended periods of time.

The new equipment, representing a great advance in direct-vision, intracardiac surgery, circulates the patient's blood through an oxygenator and back through the patient, completely by-passing the stilled heart. *The circulating pumps are powered by a ⅓ hp Leland explosion-proof motor.*

Next time *you* need a motor you can depend on—look to Leland. You'll find Leland knows how to make motors to answer your specific needs. For more information on the complete line of Leland motors and generators, write the address below today.

Leland explosion-proof motor, capacitor-start, induction-run. 115/230V, 4-pole double shaft. Underwriters Listed Class I, Group C (for atmospheres containing ethyl ether vapors, ethylene, or cyclopropane).

Another AMF Product
LELAND MOTORS

THE LELAND ELECTRIC COMPANY
Dayton 1, Ohio
Division of AMERICAN MACHINE & FOUNDRY COMPANY

Circle 471 on page 19

replacing other types for the more critical applications. Soft solder or brazing can be used to attach these terminals to the can.

This wide variety of terminal types provides mechanical and electrical characteristics covering a considerable range of requirements. Table 1 shows typical electrical characteristics for various terminals in actual use on apparatus.

From "Terminals for Sealed Apparatus" in Bell Laboratories Record, *November,* 1956.

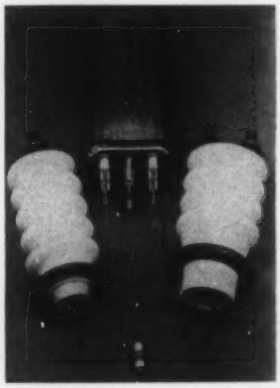


Fig. 7—Solder-sealed high alumina ceramic terminals.

Design properties of

17-7 PH Stainless Steels

MOST of the stainless steels depend on cold work to bring out their best physical properties. Such a steel is 18 Cr-8 Ni, known as type 302. In many parts, the angles of bends are such that a material in its fully hardened state cannot be successfully formed to the desired shape. To overcome this, stainless steels that can be formed in a soft state and then hardened have been developed. One of these is known as 17-7 PH, i.e., 17 per cent chromium, 7 per cent nickel, precipitation-hardening material.

Conditions: 17-7 PH is available in sheet, bar and wire in several so-called "conditions," as follows:

Condition A—annealed at 1900 F and air-cooled.

Condition C—which is condition A cold-drawn and is available in wires.

Condition CH 900—is cold-drawn and hardened at 900 F for 1 hr.

The types listed above can be treated to the following conditions:

Condition T—which is condition A material transformed by heating at 1400 F ± 25 for 1½ hr and cooled to 60 F or lower within 1 hr after removal from the furnace.

Condition TH 1050—which is condition T material heated for 1½ hr at 1050 F ± 10 and air-cooled.

Heat-Treatment: The requirements of the aircraft and missile industries for higher strengths in corrosion-resistant materials, capable of withstanding temperature environments of 650 F and higher, have prompted Armco Research Laboratories to develop a new heat-treatment for 17-7 PH stainless steel. When applied to condition A, this new heat-treatment obtains room temperature tensile strengths of 200,000 to over 240,000 psi with commensurate improvement in other strength properties.

Condition A material can be heat-treated by the fabricator to develop this higher-strength condition known as RH 950. The recommended practice for this heat-treatment is:

1. Heat condition A products at 1750 ± 15 F for 10 min, and air cool to develop condition A 1750.
2. Cool condition A 1750 to − 100 F for 8 hr to develop condition R-100.
3. Reheat condition R-100 at 950 ± 10 F for 1 hr to develop condition RH 950.

The material when obtained in condition C is solution treated and cold worked. A 900 F heat treatment develops an ultimate tensile strength of 244,000 to 345,000 psi, depending on wire diameter. Usually anything that material in condition C will make can be formed of standard 18-8 type 302 which is quite rustless and which in the finished product is cheaper.

When used in condition A, and to develop full strength, 17-7 PH requires a double heat-treatment of 1400 F, cooled to 60 F plus 950 F draw. This produces in any thickness of the material a minimum ultimate tensile strength of 185,000 psi and a yield of 165,000 psi.

Dimensional Change: This heat-treatment has caused some trouble in holding dimensions. Transformation is accompanied by a dimensional increase of 0.004-in. per in. Allowance should be made for this in laying out parts, and any holes should be made after the 1400 F heat-treatment. The final treatment of 950 or 1050 F results in an expansion of approximately 0.0002-in. per in.

Corrosion: Any heat tint on 17-7 PH is a potential source of rust, but this rust is not like that on steel. Rusting of steel is a continuous process, while in 17-7 PH, as soon as the entire piece is covered with oxide, no further rusting takes place; the surface is passivated. The rust is genuine, and pickling it off will show pits. Thus, the corrosion resistance is not as good as 18-8 stainless steel under some conditions.

From "The Properties and Hardening of 17-7 *PH Steels" in* The Mainspring, *published by Associated Spring Corp., December,* 1956.

NEW

Data-Readout Counter

Provides 100,000 Distinct Circuit Arrangements

Electrically actuated data readout counter with electric reset. Form B-1538 for 110V AC/DC.

FUNCTIONS

Analog to Digital Conversion
Serial or Parallel Circuit Transmission
Continuous or On Demand Electrical Readout
Continuous Visual Readout
Visual and Electrical Data Storage
Predetermining
Repeat Predetermining
Sequential Programming

Veeder-Root's new series of Data Readout Counters combines visual indication with electrical readout for remote indication, recording, and controlling applications. *Electrically* or *mechanically* driven and provided with *manual* or *electric* reset, these counters present a positive display of accumulated totals and automatically create specific control circuit contact closures for each number visually displayed. Each instrument, with its five figure capacity, provides 100,000 distinct circuit arrangements which lend themselves to the most exacting control and transmission requirements. The counters are compatible with standard data processing equipment and offer a wide variety of applications in the industrial control and data processing fields.

Veeder-Root Inc.

"THE NAME THAT COUNTS"

Hartford, Conn. • Greenville, S. C. • Chicago • New York • Los Angeles
San Francisco • Montreal • *Offices and Agents in Principal Cities*

Circle 472 on page 19

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Aircraft Switches

Twelve different familes of precision snap-action aircraft switches including over 70 enclosed models, are covered in illustrated catalog 77. Dimensional drawings, electrical ratings and technical data are included. Various actuator designs and contact arrangements are described. 24 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 601 on page 19

Measuring Instruments

Fold-out type condensed catalog 891B displays a diverse line of precision measuring instruments and industrial test and control equipment. Included are Variac autotransformers and motor speed controls, stroboscopes, sound analyzing instruments, oscillators, signal generators, meters, filters and frequency measuring equipment. 8 pages. General Radio Co.

Circle 602 on page 19

Gears

"Geared for Research, Design, Production" is title of brochure which illustrates facilities for manufacture of gears and machined parts. Service to automotive, aviation, appliance and other industries is emphasized. 24 pages. New Process Gear Corp.

Circle 603 on page 19

Phase Meters & Delay Lines

Folder and two supplementary data sheets illustrate and give specifications for precision phase meters, variable and tapped delay lines, voltage meters and electronic counters. Data sheets specifically cover the 9T series delay lines and type 2011 and 2012 continuously variable time delays. 4 pages. Advance Electronics Lab., Inc.

Circle 604 on page 19

Panel Wiring Raceways

Bulletin S-301 outlines new raceway techniques for wiring of electrical and electronic equipment. One section tells how corners and T's are made. A complete guide is also provided to all standard Panel Chanel raceways, giving specs, part numbers and sizes. 8 pages. Stahlin Brothers, Inc.

Circle 605 on page 19

Diesel Starting System

Diesel engines operating in deserts or arctic regions can be assured safe, instant starts with use of the GM Hydrostarter. This hydraulic starting system is described in detail in form 6 SA37. 6 pages. General Motors Corp., Detroit Diesel Engine Div.

Circle 606 on page 19

Carbon Graphite Bearings

Nonlubricated carbon graphite bearings and bushings for industry are subject of new mechanical catalog. Bearings will operate in up to 700°F under corrosive conditions. Applications in various industries are shown. 16 pages. Electro-Nite Carbon Co.

Circle 607 on page 19

Air & Hydraulic Cylinders

Literature on air and hydraulic cylinders includes bulletin 101A on 150-psi air and up to 1500 psi hydraulic (oil) cylinders, and bulletin 105 on hydraulic cylinders rated up to 2000 psi. Construction features, capacities and other data are given. 28 and 8 pages, respectively. Ortman-Miller Machine Co.

Circle 608 on page 19

Oil-Hardening Tool Steels

Typical analysis, heat treatment and forging practice regarding Ry-Alloy oil hardening tool steel are given in engineering data bulletin 14-14. Steel is supplied in rounds, squares and flats for uses ranging from arbors and clutch dogs to thrust washers and trimming dies. 4 pages. Joseph T. Ryerson & Son, Inc.

Circle 609 on page 19

Nonwoven Felt Filters

Advantages of Windsor fiber bonded nonwoven felt for liquid filtration are presented in data sheet 18. Use is on plate and frame, pressure leaf, rotary vacuum, cartridge or specialty filtration equipment. 8 pages. American Felt Co.

Circle 610 on page 19

Thermostatic Controls

Sensitive precalibrated thermostats for use on motors, cycling systems, fire alarm and sprinkler systems, appliance safety devices and regulating systems are described in engineering data booklet. 8 pages. Franklin Dales Co.

Circle 611 on page 19

Motor Selection Guide

Selection of electric motors for all popular uses is facilitated by information in this Application Guide. Motors from 1/20 hp up to 400 hp, in polyphase, single-phase and direct current types are covered. 12 pages Century Electric Co.

Circle 612 on page 19

Strain Gages

Latest domestic price list on SR-4 strain gages, instruments and accessories covers several new self-compensated gages, a line of high temperature and room temperature foil gages and an assortment of special cement kits. 16 pages. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div.

Circle 613 on page 19

Metal Liquid Filters

Design data on lubricating, hydraulic or fuel oil filters are provided in LFC catalog on capacities from 1.7 to 720 gpm. Metal screen disk filters have precisely controlled openings to assure selected degree of separation. 16 pages. Air-Maze Corp.

Circle 614 on page 19

Conveyor Chains

Bulletin 56-60 featuring both steel and Nylon TableTop conveyor chains also contains information of PlateTop roller, Crescent Top, loose-pin case conveyor and riveted case conveyor chain. A chain engineering and application section is highlighted. 24 pages. Chain Belt Co.

Circle 615 on page 19

Servo Motors

Servo motor data provided in bulletin 385 include electrical and mechanical specifications, information on direct plate-to-plate operation and transistor and magnetic amplifier

Contact points able to survive this brutal shear test stay on forever

STANDARDS THAT DETERMINE RELAY QUALITY

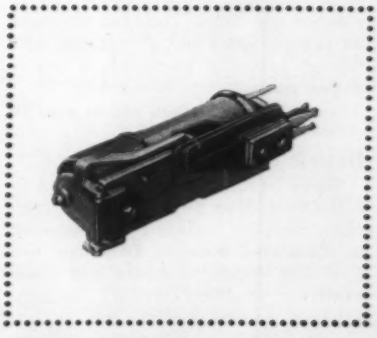
contact points that stay on for keeps

Superior attachment technique guards against insecure welds.

When you find a relay that sheds its contacts, you usually have a relay that's suffering from "cold welds"; this means that when the contact spring was made, the contact and the spring did not really weld together. When that happens, the contact is likely to fall off at any time.

We prevent that, here at Automatic Electric, by making contacts from a continuous length of precious-metal wire. In one combined operation, we weld the end of this wire to the spring blank (using very accurate control of time and voltage), pinch it off so as to provide exactly the right amount of material for the contact, and finally form it into a dome of the contact metal. Result: a contact with a polished surface, welded to the spring for the life of the relay. This is one more reason why Automatic Electric relays set performance records of 200 to 400 million operations without a failure!

This superior method is typical of the painstaking care that goes into *every* relay we make.



Class "A" Relay—for use when low first cost is important. *Write today for Circular 1702. Automatic Electric Sales Corporation, Chicago 7.* In Canada: *Automatic Electric Sales (Canada) Ltd., Toronto.* Offices in principal cities.

AUTOMATIC ELECTRIC

Originators of the dial telephone • Pioneers in automatic control

GENERAL TELEPHONE SYSTEM

servo motor applications. Motors are offered in five frame sizes and complete ranges in input voltages, frequencies and speeds. 10 pages. Norden-Ketay Corp.

Circle 616 on page 19

Gaskets & Shims

Booklet describing Color-Plast plastic washers, gaskets, shims, seals and spacers is offered with a color-coded size selector. User can select any of 12 gages from 0.001 to 0.030-in. Plastic is also supplied in roll or sheet form, cut to specifications. 4 pages. General Gasket, Inc.

Circle 617 on page 19

Flat Annular Diaphragms

Technical publication No. 31 is entitled "Instrument Notes," and is a regular publication of this company. This issue deals with the characteristics of flat annular diaphragms. 4 pages. Statham Laboratories Inc.

Circle 618 on page 19

Welding Gas Containers

Engineering report "Resistance Welding of Butane Gas Containers" deals with techniques and metallurgy of this subject. Completed tank, composed of two half-shells of deep-drawn low carbon steel joined together at the open circumferential edges, measures 1 ft in diameter by 2 ft long. 24 pages. Sciaky Bros., Inc.

Circle 619 on page 19

Molded Plastics

"Molded Plastics" catalog and "Glossary of Plastics Terms" combine to present comprehensive information on products and facilities of this custom molder. Properties of plastics are listed. Included are data on design, selection of material and typical products produced. 8 and 4 pages, respectively. Richardson Co.

Circle 620 on page 19

Electric Counters

Shape of impulses recommended to activate Sodeco Swiss-made electric-reset impulse counters is discussed in illustrated bulletin. Described are 4, 5 and 6-digit counters and their available auxiliary contact options. 4 pages. Landis & Gyr, Inc.

Circle 621 on page 19

Woven Wire Conveyor Belts

Study reports on service life of woven wire conveyor belts operating in temperature of 2050°F, the range in which copper brazing is performed. Means for increasing belt life in this service are reported. Cambridge Wire Cloth Co.

Circle 622 on page 19

Vacuum Gage

Developed for checking pressures in a range of 1000 to 0.0001-mm of mercury, model 520 Alphatron ionization vacuum gage is suitable for production or research use. It is usable with most vapors and gases. Details are given in bulletin "Vacuum Gages." 2 pages. NRC Equipment Corp.

Circle 623 on page 19

Test Equipment

Pictorial review presents organization, engineering, manufacturing and construction facilities of this firm which specializes in making equipment for testing aircraft engines, accessories and components. Typical test stands are briefly described. 34 pages. Aero-Test Equipment Co.

Circle 624 on page 19

Silicone Applications

More than 115 different applications for silicones are discussed in condensed catalog CDS-97. Uses described include rubber products, cosmetics and polishes, electrical insulation, water repellents, textile finishes, lubricants, release agents and antifoam agents. 8 pages. General Electric Co., Silicone Products Dept.

Circle 625 on page 19

Indexing Drives

Small series E roller gear drives for precision indexing of machines and instruments with low torque requirements and rates up to 2000 rpm are described in bulletin 107A. Load ratings and dimensions are given for 19 standard units with from 3 to 12 stops and indexing periods of 120, 180 and 270 degrees. 4 pages. Ferguson Machine Corp. of Indiana, Roller Gear Div.

Circle 626 on page 19

Small DC Motors

Engineering data on special-purpose 6 to 115-v, 1/75 to 1/10-hp dc motors in speed reducer, speed governor, shunt, series or compound types are given in engineering bulletin. 1 page. Induction Motors Corp.

Circle 627 on page 19

Shape-Cutting Machine

Fully portable No. 4 Monograph shape-cutting machine can be used to flame-cut metal at speeds from 3 to 30 imp within an area of 32 x 56 in. This pantograph type machine uses a motor driven tracer to follow outline of any pattern. Full details are given in catalog ADC 660B. 8 pages. Air Reduction Co.

Circle 628 on page 19

Screw Conveyor Drive

Recently introduced shaft-mounted Screw-King speed reducers designed for screw conveyor application is covered in catalog SCD-57. Units are offered in 5:1, 13:1 and 20:1 reductions for conveyors requiring up to 10 hp and speeds from 15 to 290 rpm. 8 pages. American Pulley Co.

Circle 629 on page 19

Powdered Metal

Technical data on the design, engineering and applications of bearings, machine parts, infiltrated parts, plated parts and pole pieces made of powdered sintered metal are presented in "Engineering Handbook on Powder Metallurgy." Charts, photos and drawings amplify the text. Bunting Brass & Bronze Co.

Circle 630 on page 19

Lock-Down Pushbutton Switch

Data sheet 116 descriptively covers the new Micro Switch lighted pushbutton switch. Switch button, when pushed and turned 30 degrees, stays down to maintain operated position. It is rated 5 amp at 125 or 250 v ac. Minneapolis-Honeywell Regulator Co., Micro Switch Div.

Circle 631 on page 19

Stainless & Aluminum Fasteners

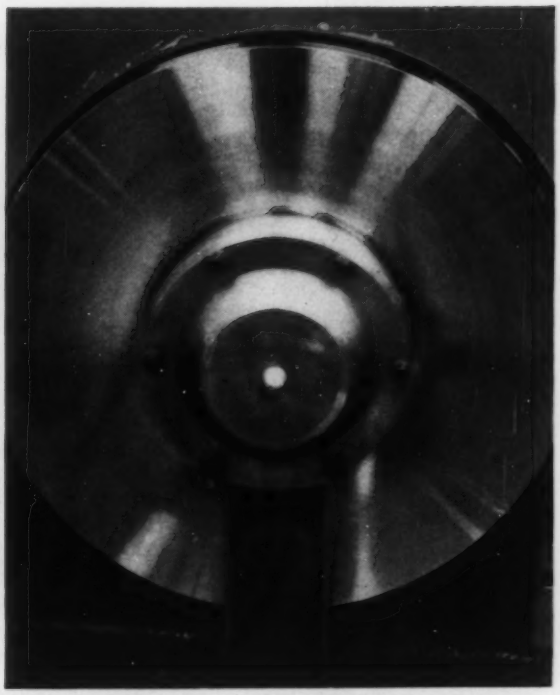
Complete line of stainless steel and aluminum thread cutting screws, sheet metal screws, machine and cap screws, washers, bolts, nuts and special fasteners is described in new brochure. Fasteners are also made in brass, steel, silicon, phosphor bronze and other metals. 4 pages. Accurate Threaded Fasteners Inc.

Circle 632 on page 19

Strain Gages

"SR-4 Transducers and Instrumentation" gives complete specifications and prices on load or force measuring, pressure measuring and torque measuring devices, and on miscellaneous instrumentation and accessories. 16 pages. Baldwin-Lima-Hamilton, Electronics & Instrumentation Div.

Circle 633 on page 19



Self-locking UNBRAKO socket screws keep critical adjustments secure in the eccentric drive mechanism of this fatigue testing machine. Drive system delivers varying loads up to 15,000 pounds force to equipment under test at 1050 cycles per minute.

Vibration won't loosen Self-locking UNBRAKO socket cap screws

Screws with Nylok* device permit adjustments, keep precise settings during long test runs

HOW IT LOCKS. The tough, resilient Nylok locking pellet keys itself into the mating threads. It forces threads together, and locks the screw securely—whether or not the screw is seated.

UNBRAKO socket screws with the Nylok self-locking device stay tight under constant vibration.

Take the eccentric drive system in the fatigue testing machine illustrated above, for example. This machine must frequently run for periods up to 2 weeks or longer, day and night, to complete a single test. Loosening of the screws which are used to adjust the tension-setting mechanism could not only cause damage to the machine, but also make the test data worthless. Self-locking UNBRAKO socket head cap screws eliminate such problems.

An UNBRAKO socket screw with the Nylok self-locking device is a single unit. Just screw it into any tapped hole. Seated or not, it locks positively wherever wrenching stops. Constant vibration or pounding, or endless running of a machine, won't affect these self-locking UNBRAKOS. The screws will not work loose!

Write today for your copy of Form 2193, which gives complete catalog and technical data on the entire line of UNBRAKO socket screws with the Nylok self-locking device. Or see your authorized industrial distributor. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

UNBRAKO® SOCKET SCREW DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN ■ PENNSYLVANIA

*T.M. Reg. U.S. Pat. Off. The Nylok Corporation

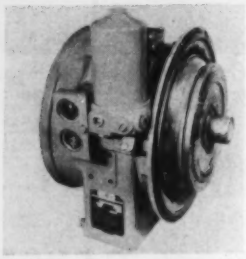
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Torque Converter

for engines with torque to 350 lb-ft

Single-stage torque converter is designed for high-speed diesel and gasoline engines producing from 30 hp at 1450 rpm to 212 hp at 3200 rpm. Specific torque ratings are



165, 200, 240, 285 and 330 lb-ft, depending on impeller blading selected. Maximum input torque is 350 lb-ft. Unit has SAE No. 2 engine flywheel housing and SAE No. 2 or 3 output housing. **Twin Disc Clutch Co.**, Hydraulic Div., Rockford, Ill.

Circle 634 on page 19

Pressure Switch

sustains burst pressures to 1000 psi

GPI-2000 subminiature pressure switch for pressure indication makes and breaks a 6 to 8-v re-

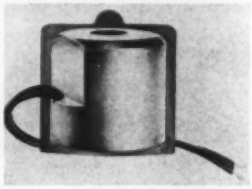
sistive dc circuit and carrys up to 250 ma. It operates satisfactorily after subjection to violent physical and environmental shocks encountered in missile and aircraft applications. Available in pressure ranges from 50 to 500 psi, the unit sustains burst pressures to 1000 psi. Custom designed, each unit meets requirements of MIL-T-5422C. **Gorn Electric Co. Inc.**, Aircraft Controls Co. Div., 845 Main St., Stamford, Conn.

Circle 635 on page 19

Solenoid Coil

is processed with epoxy resin

Kast-Coil solenoid coil assembly, processed under vacuum and cured electronically, features void-free, high-density casting. It has high resistance to thermal shock and physical abuse, is impervious to corrosive fumes, and is completely



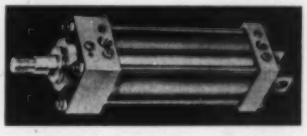
waterproof. Coil is available for continuous service under rated conditions. **Hays Mfg. Co.**, Dept. 423-A, West 12th St., Erie, Pa.

Circle 636 on page 19

Fluid Cylinders

are easily and quickly maintained

Squarehead S fluid cylinders are rated at 250 psi for pneumatic use, or up to 1000 psi hydraulic service, and are available in 7 bore sizes up to 6 in. Rod end has a rod cartridge solidly locked to the head by a tightly coiled stainless-steel spring which is seated in matching grooves in head and cartridge. By removing one screw, the spring can be stripped out and rod cartridge removed, allowing quick replacement of parts. Other features include chrome-plated steel



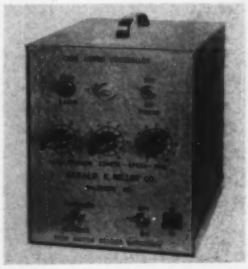
tube, chrome-plated manganese-steel piston rod, prestressed tie rods for equal load distribution, and full floating cushions to eliminate misalignment and provide better fit between cushion members. Cylinders are built to JIC recommendations. **Teer-Wickwire & Co.**, Lindberg Air & Hydraulic Div., 1877 Wildwood Ave., Jackson, Mich.

Circle 637 on page 19

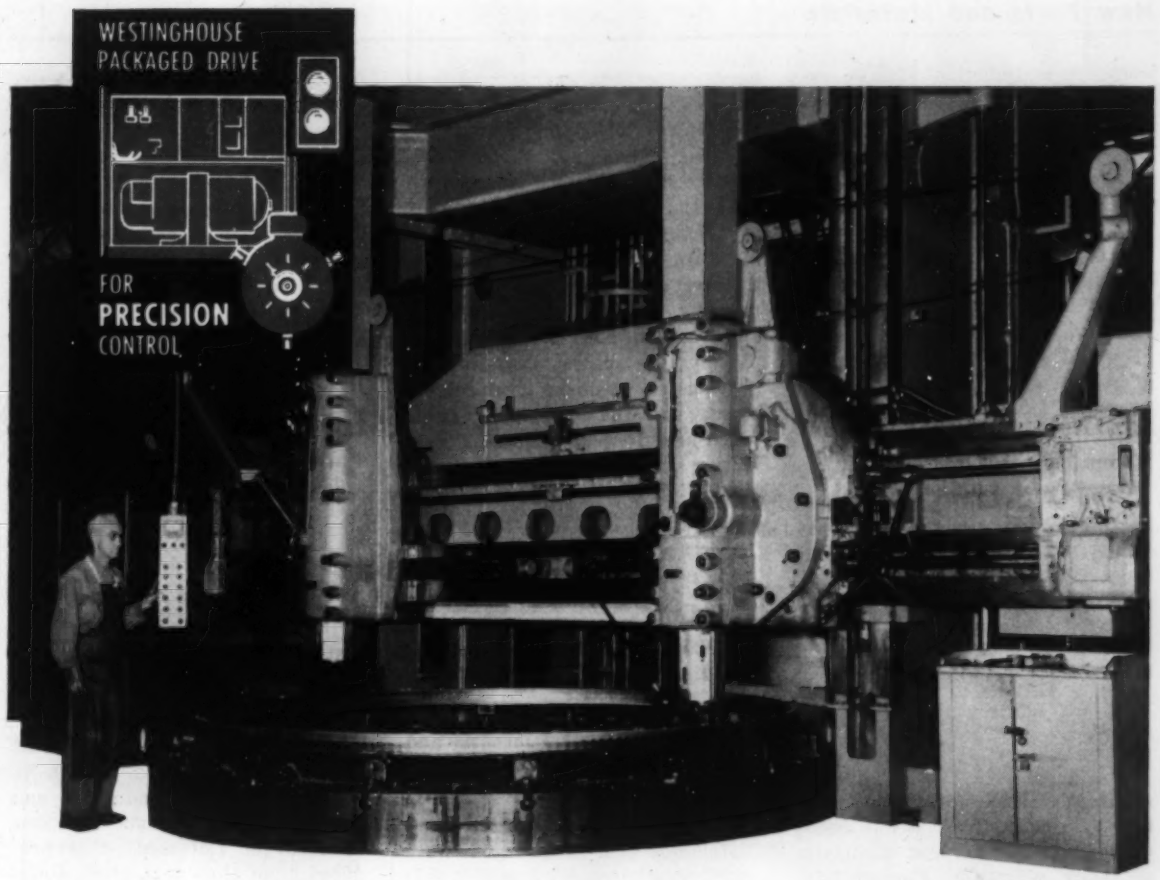
Speed Controller

starts motor at any speed from 1 to 2200 rpm

CX25 electronic controller provides accurate acceleration and speed control of shunt-wound dc motors from 1/50 to ¼ hp. Motor



can be started at any speed from 1 to 2200 rpm either immediately or gradually over a 30-second interval. Fine speed adjustment



"Adjustable-speed Westinghouse AV-DRIVE tripled production on our 14′ boring mill,"

says Chief Engineer, Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Burnham, Pa.

A twist of the dial at the pendant operator's station controls a speed range of ½ to 22¼ rpm on this vertical boring mill equipped with Westinghouse AV Drive. Precision control of the 75-hp Westinghouse d-c motor produces the work formerly done by *three* belt-driven mills operated by Standard Steel Division.

In addition to the precision and adjustable speed necessary for turning, facing and boring weldless steel rings, the 19 Westinghouse AV Drives now in use give Baldwin-Lima-Hamilton the versatility needed for profitable use of their huge metal-working facilities.

To learn how the versatile Westinghouse AV Drive can make your production more profitable, call your local Westinghouse representative or write Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-22014

AV Drive, providing on-the-spot conversion of plant distribution system a-c voltage to the required direct current for precision control of the drive motors.

YOU CAN BE SURE... IF IT'S Westinghouse

Circle 475 on page 19

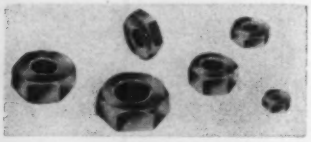
works in conjunction with coarse speed control. Motor speed is accurately and steplessly varied by as little as 220 rpm with 270 deg of speed pot rotation. Unit operates on one c3j thyratron tube that automatically increases voltage to compensate for additional loading of motor armature. **Gerald K. Heller Co.,** 1819 Industrial Rd., Las Vegas, Nev.

Circle 638 on page 19

Brass Nuts

from bar stock are countersunk both sides

Brass machine-screw nuts, machined from high tensile strength brass rod, are countersunk both sides. Threads are absolutely



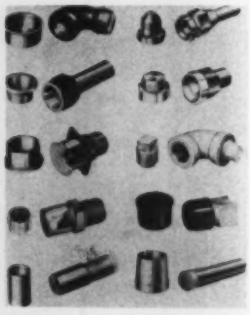
square with both faces of nut, making them suitable for use in automatic nut running and automatic assembly operations. **Cornell Mfg. Co.,** 20 Saw Mill River Rd., Yonkers, N. Y.

Circle 639 on page 19

Caps and Plugs

of flexible polyethylene plastic

CaPlugs include caps and plugs in ten different designs and over 300 sizes. Styles include: tapered units with wide, thick flanges; non-



threaded caps and plugs for electrical receptacles and connectors; threaded caps and plugs for tight sealing of threaded fittings; threaded pipe plugs with square heads adaptable to hand or mechanical tightening; nonthreaded sleeve caps to fit snugly over the outside diameter of tubing; and nonthreaded tubing plugs with flanges to fit flush with outer walls of tubing. Suitable as dust and moisture seals and shipping protectors, units are also used for masking during dipping, painting and vacuum plating. Of flexible polyethylene plastic, they are impervious to common chemical reagents and will not chip, break or shred under severe conditions. **Protective Closures Co. Inc.,** CaPlugs Div., 2207 Elmwood Ave., Buffalo 23, N. Y.

Circle 640 on page 19

Dynamotor

withstands vibration and mechanical shock

Model BD 1509D dynamotor, for application in guided missiles and telemetering installations has power output of 10 w continuous, ranging up to 25 w depending on duty cycle and cooling. Unit has brush

life of 100 hr at 50,000 ft and operates in ambient temperature range of −40 to 71 C. When subject to vibration, dynamotor withstands more than 3 *g* from 5-600 cps, along three mutually-perpendicular axes. Under mechanical shock it absorbs up to 40 *g* in any direction. Unit weighs 1 lb and measures 1½ x 1½ x 3 in. **Induction Motors Corp.,** 570 Main St., Westbury, L. I., N. Y.

Circle 641 on page 19

Valve Stem Packings

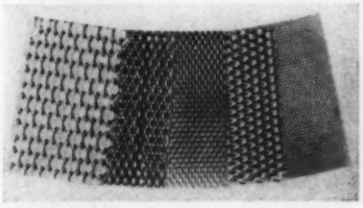
utilize inconel wire in packing jackets

Two asbestos-braid jacketed plastic-core valve-stem packings for high pressure and/or high temperature service utilize inconel wire in packing jacket. Style 5855 is for general-service stem - valve packing at stuffing box temperatures from 500 to 600 F and pressures of several thousand psi. Style 127 is for use in packing any fluid which will not affect the asbestos. It is suitable for extreme heat conditions, such as at 750 F, and pressures to several thousand psi. **Garlock Packing Co.,** Palmyra, N. Y.

Circle 642 on page 19

Expanded Metal

with openings from 1/16 to 2½ in.



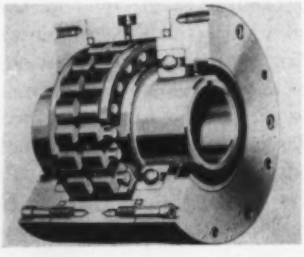
Micromesh expanded metal with openings from 1/16 to 2½ in. is available for many industrial and decorative applications. Either standard or flattened, it is produced from aluminum, steel, stainless steel, copper, brass, monel or any standard sheet material. Diamond shapes are the basic pattern, with square and tear drop openings in the development stage. **Designers Metal Corp.,** 564 E. 159th St., Harvey, Ill.

Circle 643 on page 19

Sprag Clutches

ball-bearing units for indexing applications

Series B and C sealed double-ball bearing sprag clutches, for overrunning, indexing and backstop-



ping purposes, are for application where retention of light oil is essential to long life and accurate operation, and for situations where

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Factor of Safety— make it a reality

You can't calculate that with a bolt having yield strength of 4 times the working load you're automatically getting a *safety factor* of 4. Far from it. Only when the bolt is *tightened* to four times working load do you get it.

That's because rigidly fastened members can be externally loaded to the full value of residual tension in bolts without any separation or extra bolt stress.

Suppose you need a bolt for a 5000 lb. working load. For a X4 safety factor, you use a bolt of 20,000 lb. capacity, and tighten it to 20,000 lb. tension. If you tighten to only 10,000 lbs., any external load larger than this causes loosening, and progressive bolt failure from fatigue. So your safety factor is really only 2.

PRODUCTION MAN FOLLOW-THROUGH IMPORTANT

Factor of safety, then, is not established on the drawing board. It can only be put into the product by the shop man with wrench. In short, a bolt is no better than the supervision of its tightening.

A NOTE ON FLEXIBLE JOINTS

This case is different. You tighten such a joint just to working load. So use a bolt capable of this *plus* any added stress *multiplied* by your safety factor.

How to simplify bolt and nut usage

DESPITE their now unified dimensions, "standard" fasteners number thousands upon thousands of different types and sizes. More and more companies are beginning to realize that *usage* simplification offers advantages.

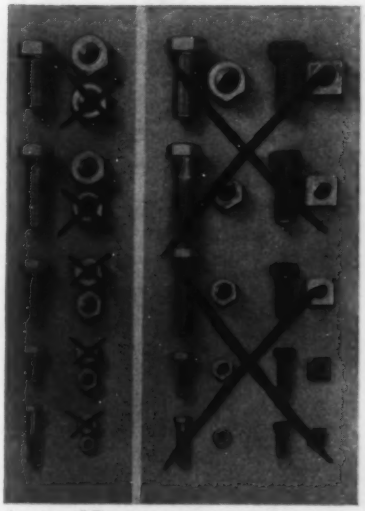
EXAMPLES

A well known electrical manufacturing company finds it no handicap to eliminate all 1/16" bolt sizes above 3/8", thereby simplifying production and purchasing.

One engineering firm eliminated 1700 different fastener items from inventory by determining that the jobs could be done as well by other sizes or types.

SOME SUGGESTIONS

To guide your thinking, RB&W points up the following ways to simplify: (1) Forget thread fits for all but specialized needs – standard "tolerance fits" have thoroughly proved themselves. (2) Why adhere to double thread standard when coarse threads prove stronger and assemble faster? (3) Stick with hex head bolts – they do better jobs than square. (4) It can save money to change diameter or length, rather than to add another item to stock. (5) Two standard physical grades meet most load range requirements – do you really need special alloys? (6) Heavy nuts really belong with larger size bolts – use finished nuts with the smaller sizes.



Here is a graphic display of possible simplification. From a typical array of fasteners, it shows what may be superfluous for meeting the requirements of proper fastening in a great many instances.

RB&W would be happy to enlarge on these facts, and help you simplify fastener selection to get proper joint strength and cut assembly time and inventory. Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

High strength bolts save costly crane

At one company's plant, a large, heavy-duty crane had deteriorated due to rivets loosening. Replacing with new rivets was no permanent answer, but RB&W high tensile bolts were.

Used with hardened washers, these RB&W bolts clamp members together so tightly, no slipping into bearing takes place, holes are reinforced against fatigue, and connections become vibration-proof.

Assembling heavy duty equipment with RB&W high strength bolts in the first place can avoid such problems and create more satisfaction with the product.

Circle 476 on page 19

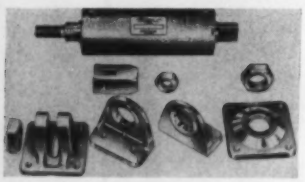
abrasives are present in the atmosphere. Series B is recommended for true over-running applications, for low-speed service where inner race over-runs (where both races rotate during some portion of cycle). It is available in bore diameters from 2¼ to 5½ in., with torque capacities from 1,875 to 11,600 lb-ft. Series C is for indexing and backstopping applications. It is available in bore diameters from 2¾ to 5½ in., with torque capacities from 3,160 to 11,600 lb-ft. **Formsprag Co.,** Application Engineering Dept., 23601 Hoover Rd., Van Dyke, Mich.

Circle 644 on page 19

Air Cylinders

corrosion-resistant units for pressure to 200 psi

Economair series cylinders in 1½ and 4 in. bore sizes are designed for air or hydraulic service to 200 psi. Cylinders feature internal feed-ring locking of heads to cylin-



der, eliminating bulk of cast heads. Noncorrosive construction utilizes seamless brass tube, stainless-steel rods and aluminum heads and pistons. Industrial O-ring seals are used throughout. Standard cushion and noncushion models are available. **Modernair Corp.,** 400 Preda St., San Leandro, Calif.

Circle 645 on page 19

Identification Plate

in either fiber or aluminum

Name plate is used to identify control-panel components, motors, limit switches, terminal boxes and other equipment mounted on machinery. Plates are available in either fiber or aluminum. Figures are white, engraved on dark fiber or black anodized aluminum background. Plates form a strong, permanent, heat-resisting bond when applied to any surface. They are marked with JIC standard identifications, are ⅜-in. high and 1 in. wide. **E. C. P. Corp.,** 6808 Wade Park Ave., Cleveland 3, Ohio.

Circle 646 on page 19

Proximity Control

has no contact with surface

MEK-3030 electronic proximity control detects the presence of an insulator or conductor at the de-

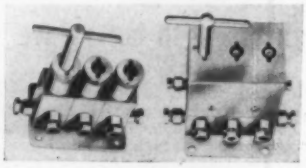
tecting point without making contact with the surface. It can be used in many ways, including use as a limit switch which requires no physical contact with controlling surface, as a level control of materials such as soap, coal and oil, and as an interface control between two dissimilar fluids. Specifications include input voltage of 115 v, 60 cycles, line consumption of 25 va, relay capacity, 5 amp, 115 v, and SPDT contact. **Machinery Electrification Inc.,** Northboro, Mass.

Circle 647 on page 19

Manifold Valves

for pneumatic installations have no hand wheels

Models 1583 and 1563 manifold valves are suitable for pneumatic instruments and control installations and other pneumatic systems.



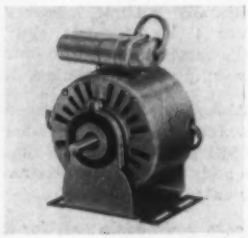
Model 1583 consists of a two-position piston sliding in a two-port cylinder, and is normally closed. Valve is moved to open position by inserting and turning a key one-quarter turn. When key is withdrawn, valve closes automatically under spring tension. Model 1563 is a duplex unit consisting of two mechanically linked two-port, two-position piston-type valves normally held closed by spring tension. When key is inserted and given one-quarter turn, both valves are simultaneously moved to open position. Valves close automatically upon withdrawal of key. **Petrometer Corp.,** Long Island City, N. Y.

Circle 648 on page 19

Fractional-HP Motor

for air conditioning and air-moving equipment

Model D-4 fractional-horsepower, permanent split-capacitor motor for air conditioning and related air-moving equipment is only 4⅝ in. in diameter for mounting inside a blower wheel. It can be installed in horizontal, vertical or



inclined positions. Unit is available with ratings from 1/150 to 1/5 hp, 115, 230 or 208 v, 50 or 60 cycles, and 2, 4, 6 or 8 poles. Single or multiple speeds are: 2-pole, 3400 rpm; 4-pole, 1600 rpm; 6-pole, 1050 to 1100 rpm; and 8-pole, 750 to 800 rpm. **Marco Industries Inc.,** 3rd and Franklin Sts., Womelsdorf, Pa.

Circle 649 on page 19

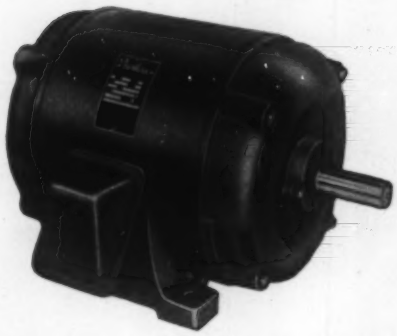
Orlon Felts

for wet or dry filtration are chemically shrunk

Chemically shrunk Orlon felt materials are available for industrial wet and dry filtration applications and other uses where a complete felt structure is required. They are manufactured in weights from 8 oz to 8 lb per sq yd. The mate-

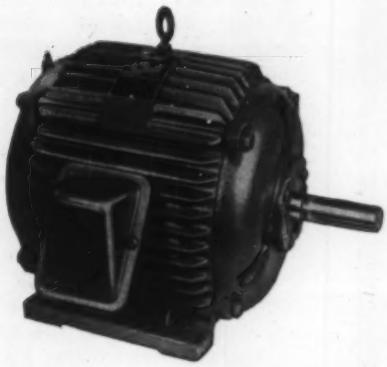
NEMA RERATED FRAME DESIGNS

Let Peerless engineers show you how these new frame designs can be modified to meet your mounting or other problems. They will show you how you can preserve, in production, the efficiency you put into your machine in design. See your nearby representative today or write direct. There's just one motor that will power your product best. Peerless will work with you to design and build it.



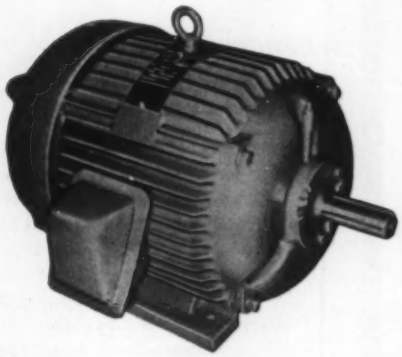
DRIP-PROOF (Open Type)

Frame sizes from 56 thru 326. Cast-iron construction. Furnished with ball or sleeve bearings. All exterior surfaces are smooth and symmetrical. Streamlined design affords complete protection against dripping liquids or falling particles.



TOTALLY ENCLOSED NON-VENTILATED

Totally enclosed, non-ventilated, from 1/2 to 3 HP. Recommended for use in non-explosive abrasive dust, metal dust, or where foreign matter may enter a motor. Positive protection of motor windings. Same design used with larger motors that drive propeller-type fans where the fan blows cooling air directly over the motor.



TOTALLY ENCLOSED FAN-COOLED

Totally enclosed, fan-cooled, from 1/2 to 30 HP. Cooling air is drawn by an external fan across the motor towards the driven machine. Heat generated by the machine is not drawn across the motor. Same system used in standard, fan-cooled motors and explosion-proof designs.

ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

FANS · BLOWERS · MOTORS · ELECTRONIC EQUIPMENT

1520 W. MARKET ST. · WARREN, OHIO

Circle 477 on page 19

NO ONE FILTER MEETS ALL DESIGN NEEDS . . .

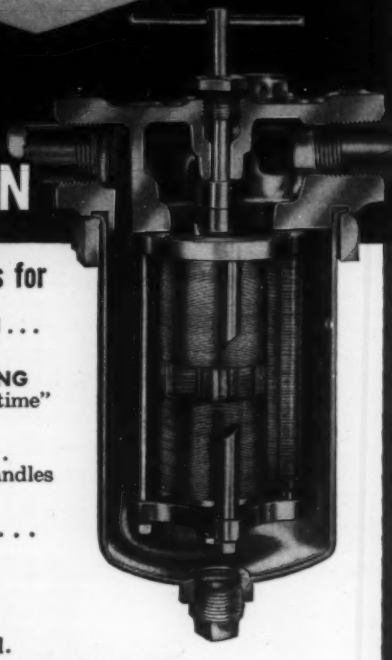
and Only CUNO offers you

5 DISTINCT TYPES OF FILTER MEDIA

♦ EDGE-TYPE ♦ WIRE-WOUND ♦ SCREEN
♦ FIBER CARTRIDGE
♦ POROUS METAL

consider

Super AUTO-KLEAN



where filter design calls for

- **MICRONIC FILTRATION . . .** down to 40 microns
- **POSITIVE, SELF-CLEANING ACTION . . .** no "down time"
- **SMALL SIZE plus HIGH FLOW RATES . . .** 12" unit shown here handles over 50 gpm
- **LOW PRESSURE DROP . . .** less than 3 psi

All-metal construction,
carbon or stainless steel.
Two-stage filtration. Lowest cost-per-gallon.

COMPLETE DESIGN-ENGINEERING SERVICE

There is a Cuno Field Engineer conveniently located in your area. To help you solve your design problems, this trained specialist offers you *more years of experience* in removing *more sizes of solids* from *more kinds of fluids.*

WRITE FOR DATA

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Send now for your free copy of Cuno Catalog No. SAK-057 containing complete engineering data. See how this high-performance filter can help your designs achieve new efficiency.

CUNO ENGINEERING CORPORATION

1404 SOUTH VINE STREET, MERIDEN, CONN.
Filtration Engineers in Principal Cities

New Parts

rials are suitable for use in applications formerly filled by woven Orlon structures based on continuous filament yarn, no longer commercially available. **American Felt Co.**, Glenville, Conn.

Circle 650 on page 19

Silicon Transistors

operate at high temperatures

NPN grown-junction high-temperature type silicon transistors have power gains from 34 to 40 db. Increased emitter diode ratings make possible the employment of

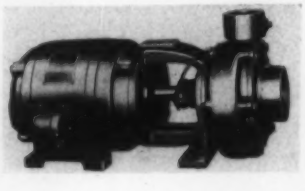
the transistors in large signal applications, such as in computers, servos and magnetic amplifiers. Standard units have emitter voltage of 1 v; special types are available with emitter voltage of 5 v. Lower series resistance on the collector side of the transistors makes switching applications more feasible and results in higher power efficiency in amplifier applications. Units operate at very high temperatures and can be stored in a temperature range of −55 to 175 C. **Bogue Electric Mfg. Co.**, 52 Iowa Ave., Paterson 3, N. J.

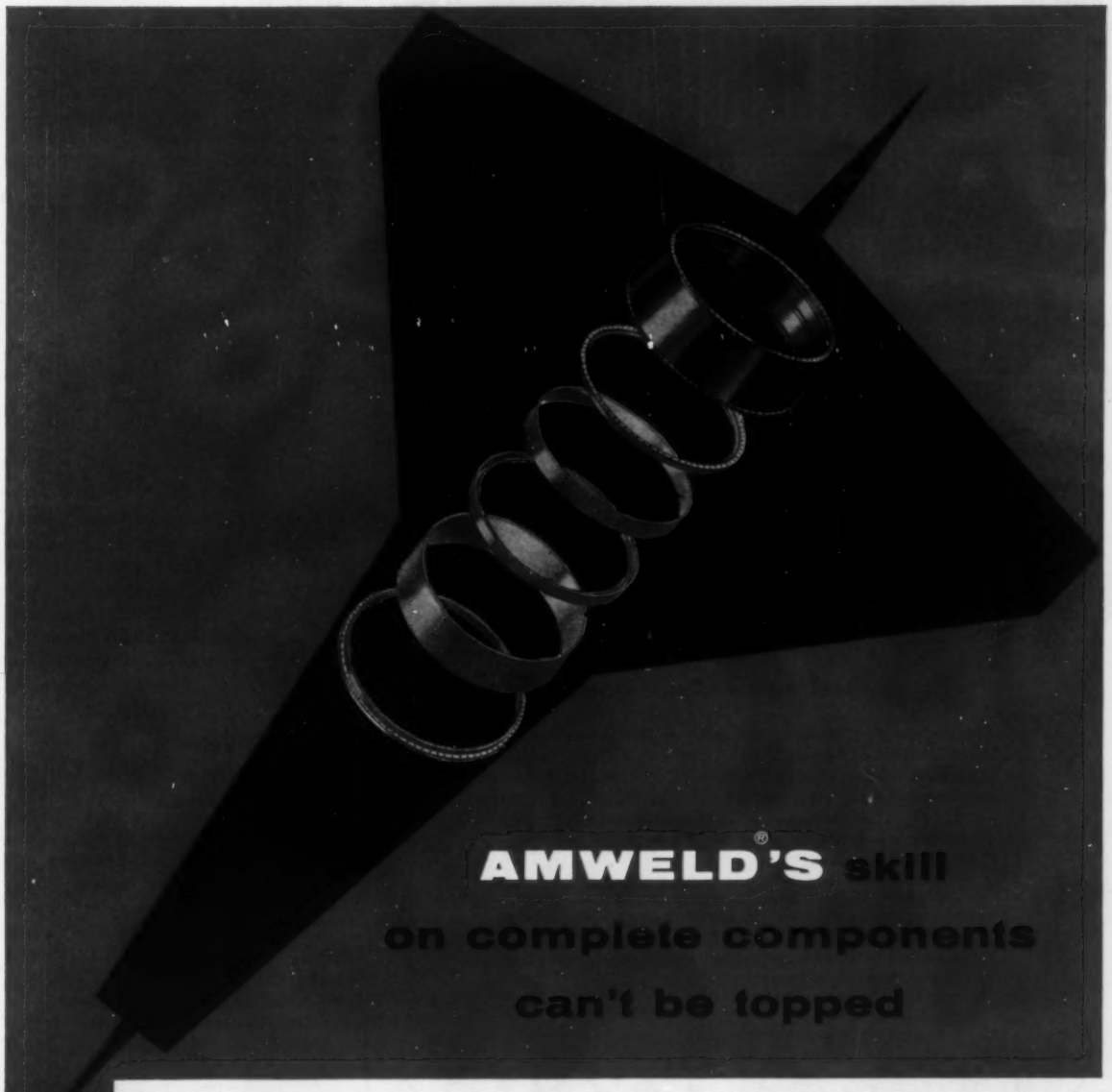
Circle 651 on page 19

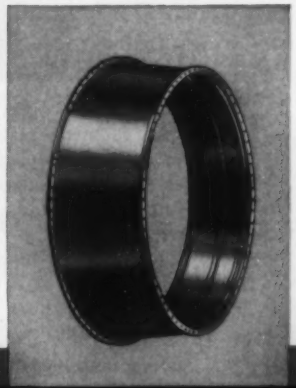
Centrifugal Pumps

motor-mount units deliver up to 1200 gpm

Three Motor-Mount centrifugal pumps are for use in manufacturing, chemical, paper, contracting and other industries, as well as for integral parts of various types of machinery. They deliver up to 1200 gpm with heads up to 220 ft. Design incorporates one - piece shaft, stainless-steel shaft sleeve







As a supplier of welded rings and components to major United States jet engine manufacturers, American Welding has proven its skill as part of an industry where cost and precision are vital factors. As the missile and rocket programs grow from the experimental to the production stage, Amweld's experience and skill can play a part in these essential programs.

If you have a problem that can be solved by a rolled and welded ring or component, or any welded fabrication, contact American Welding's Industrial Products Division. Their skill, experience, and engineering are at your service.

THE AMERICAN WELDING & MANUFACTURING COMPANY
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The World's Leading Manufacturer of Welded Rings

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

PRECISION MACHINE SCREWS

Make it Easier to Sell!

. . . because with high quality fasteners your product earns a reputation for better performance and longer life service. Experience proves that the initial higher cost of quality components is offset time and time again by such things as operating efficiency, good appearance, better accuracy, etc.

Better Steel means Better Quality

The carbon steel heading wire used in the production of standard Hubbell Screws is A.I.S.I. Grade C-1010. Special application screws with higher strength or torque value requirements are produced from A.I.S.I. Grades C-1013, C-1020 and C-1035. Those subjected to drilling or subsequent tapping operations are produced from A.I.S.I. Grades C-1108 or C-1110.

All carbon steel wire used in the production of Hubbell screws, regardless of grade, is annealed in process material to specified tensile strength and is drawn to restricted size tolerance to insure the high Hubbell standards of quality and size in the finished screws.

Prices and delivery on request. Simply send blueprint or sample of the item.

HARVEY HUBBELL, INC.

HIGHEST QUALITY WIRING DEVICES • MACHINE SCREWS

OVER 60 YEARS' EXPERIENCE in the manufacture of highest quality, rolled thread machine screws and special cold headed parts.

MACHINE SCREW DEPARTMENT BRIDGEPORT 2, CONNECTICUT

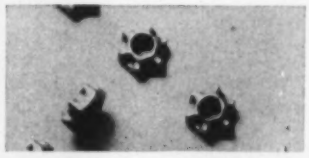
New Parts

and enclosed-type impeller with nonoverloading characteristics. Pumps are furnished with either stuffing box or mechanical shaft seal. **Deming Co.**, 800 Broadway, Salem, O.

Circle 652 on page 19

Steel Locknuts

offer weight-saving advantages



Lightweight locknuts yield weight savings to 43 percent over conventional units. Sizes are No. 10-32 and ¼-28. Nuts conform to AN-N-10 and MIL-N-25027 specifications. **Standard Pressed Steel Co.**, Stewart Avenue, Jenkintown, Pa.

Circle 653 on page 19

Hydraulic Valve

is designed for 1500-psi pressure

Model 5835 four-way ball-detent hydraulic valve is oil-pressure operated by oil pilot valve. Inlet is connected with one cylinder port and exhaust with the other when pilot pressure is applied on the right side of valve. Oil flow is reversed when pilot pressure is applied to left side. Designed for 1500 psi pressure, valves are avail-

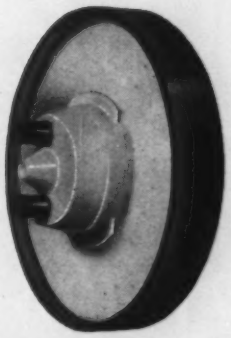
able in seven sizes from ¼ to 1½ in. Floating piston design assures leakproof operation and provides smooth, positive opening and closing. **Rivett Inc.**, Brighton 35, Boston, Mass.

Circle 654 on page 19

Wiring Channel

speeds installation of circuit wiring

Glastic Channel-Duct is a 3-sided wiring duct for simplifying panel



Rear Views showing Bulb Holders in Flush Mounted and Face Mounted Lamps

Truck-Lite created a

bright new idea in truck lighting

—Sylvania custom molded it

Truck-Lite's new all plastic, sealed, "throwaway" lamp unit is a light-saving, maintenance-saving idea in truck clearance and marker lamps.

Its rustproof, shatterproof plastic lens was designed by Truck-Lite and Sylvania for brilliant wide-angle illumination. Throwaway feature combined with simple plug-in receptacle is a boon to truck-light maintenance.

Custom molding of intricate parts like the Truck-Lite lens and bulb holders is just one of the reasons leading manufacturers, large and small, come to Sylvania for consultation on parts designs.

Sylvania's Parts Division also offers complete facilities for custom metal stampings, special electronic components and special wires. For complete details of these services, write for the "Portfolio of 4-way Service to Designers."

The *Truck-Lite* lens is molded of heat-resistant methacrylate in red, green, amber and crystal. The angle of its refraction prisms (a) are molded in graduations of 1° to produce controlled illumination over a full range of 180°.

Mounting surface of the lens (b) is held to ±.002″ to insure proper seating of bulb holder and accurate positioning of the light with respect to the truck body.

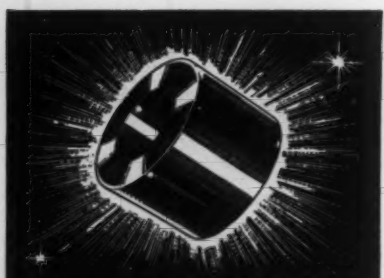
SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

SPECIAL WIRE | METAL STAMPINGS | MOLDED PLASTIC | ELECTRONIC COMPONENTS | 4-way service from one source

Circle 481 on page 19



GET THE FACTS ON

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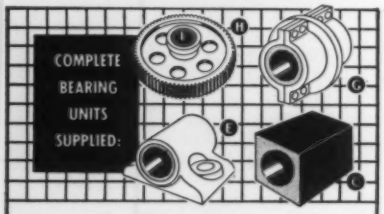
LONG WEARING
LOW FRICTION

UNIQUE (OIL-FREE)

SELF-LUBRICATING
BUSHINGS

EXCELLENT DURABILITY • CONSTANT COEFFICIENT OF FRICTION • APPLICABLE OVER A WIDE TEMPERATURE RANGE (−450° to +700°F.) OPERATE DRY, OR AT HIGH SPEEDS SUBMERGED IN WATER, GASOLINE OR LIQUID GASES • NON-CONTAMINATING IN FOODSTUFFS • EXCELLENT FOR CURRENT-CARRYING BEARINGS

GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



BRUSHES • CONTACTS

GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

USE OUR 40 YEARS OF DESIGN EXPERIENCE!

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☐ Please send data on Graphalloy Oil-Free BUSHINGS.
☐ Send data on BRUSHES and CONTACTS.

NAME & TITLE
COMPANY
STREET
CITY ZONE STATE

Circle 482 on page 19

New Parts

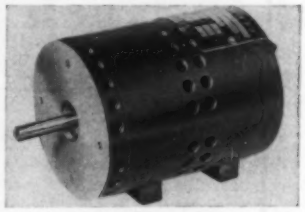
wiring and is available in 2-in. high size. Duct lowers fabrication and assembly costs. Wires are laid in duct, strung through holes to proper connection points, and cover is snapped on. **Glastic Corp.**, 4321 Glenridge Rd., Cleveland 21, O.

Circle 655 on page 19

Induction Motor

for airborne applications

Induction-type, 550 rpm, 8-pole aircraft motor for fan, pump, and actuator applications operates on 3-phase, 400 cps, 200 v ac and delivers ½-hp continuously at 50,000 ft altitude. Weight is 4½ lbs. Motor is flange mounted to driven equipment and is available with



either extended or standard shaft. **U. S. Electrical Motors Inc.**, Box 2058, Terminal Annex, Los Angeles 54, Calif.

Circle 656 on page 19

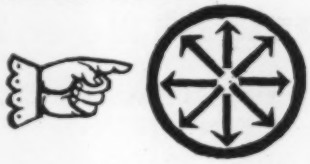
Stretchable Cord

stretches to six times normal length

Electric cord for use on telephones, switchboards, appliances and similar applications will stretch to six times its original length. Cord has a rubber-core base for braided or wound copper wire. Coating around wire may be glass fiber, rayon, silicone rubber or nylon. Three sizes are available with clip, jack or spade terminals. Any color of coating is available. Cable will not twist or lose its elasticity, and con-

Nature abhors a vacuum

but a sphere resists pressure best of all



So when you're in a vacuum for ideas—or under pressure to produce—remember a ball!

A *perfect* ball (Universal makes them to tolerances of 10 millionths of an inch!) may be the perfect starting point for the answer to your problem.

You can start rolling on a ball of almost any type metal —and move in any direction!

Yes, Universal balls offer limitless possibilities to the designer and manufacturer. They'll move with any idea.

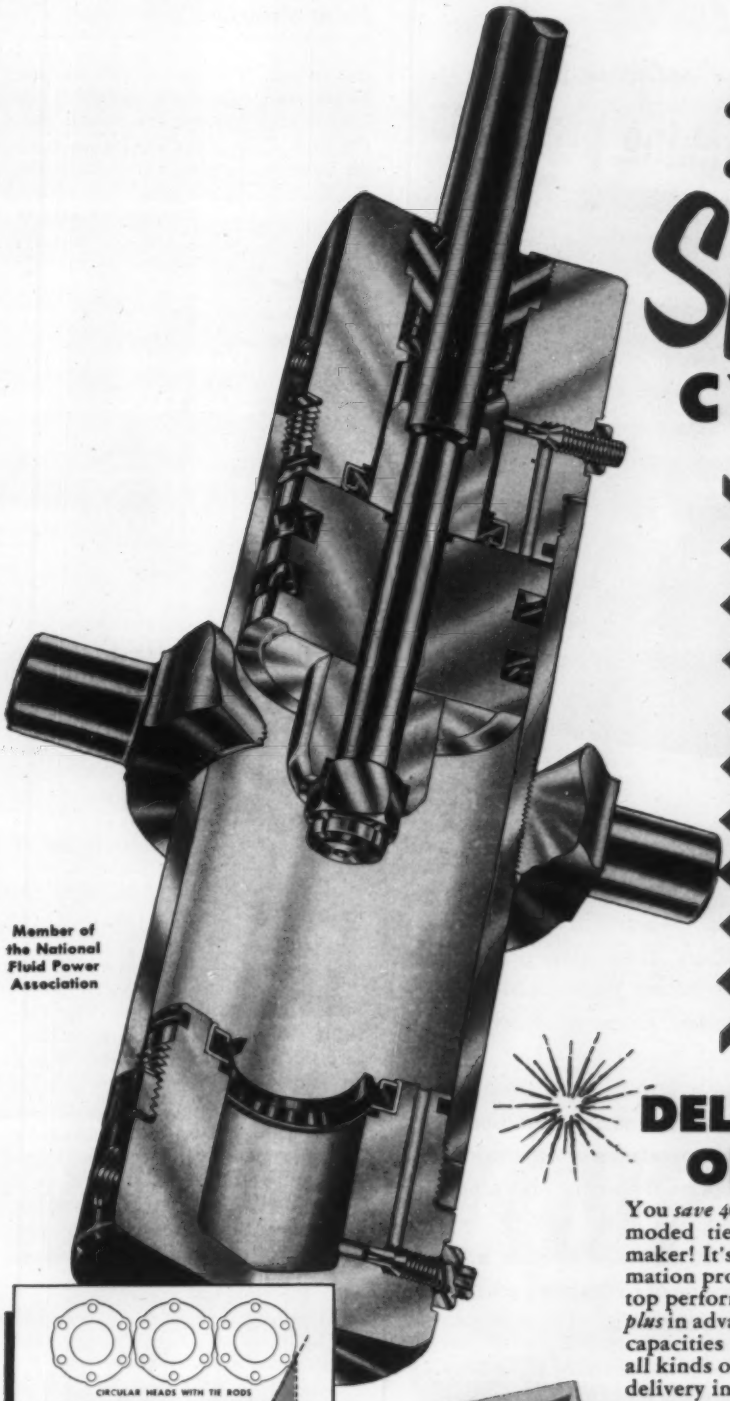
UNIVERSAL QUALITY CONTROL— FOR ALL AROUND PERFECTION

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

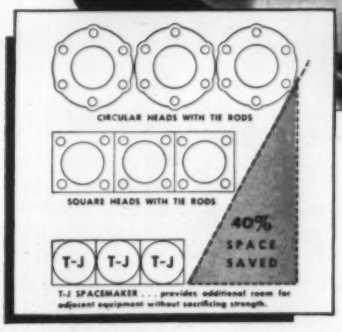
Circle 483 on page 19

all the EXTRAS are standard with T-J Spacemaker CYLINDERS



Member of the National Fluid Power Association

- **NEW** *exclusive* ingenious cushion designs . . . Super Cushion Flexible Seals for Air . . . New Self-Aligning Master Cushion for Oil.
- **STRONGER** than outmoded tie rod design, proven through actual tests. No tie rods to stretch.
- **SOLID STEEL HEADS** throughout the full line.
- **COMPACT DESIGN** eliminates tie rods, increasing the strength and reducing mounting space required, providing extra room for adjacent equipment.
- **HARD CHROME PLATED** body bores and piston rods . . . assure you of long trouble-free service. (Standard at no extra cost.)
- **METALLIC ROD SCRAPER,** not just a wiper, actually removes foreign matter from the rod.
- **PILOTED PACKING GLAND** with extra long bearing. Additional strength and support to the piston rod.
- **OIL** pressure to 750 p.s.i. AIR to 200 p.s.i.


CIRCULAR HEADS WITH TIE RODS
SQUARE HEADS WITH TIE RODS
40% SPACE SAVED
T-J
T-J
T-J
T-J SPACEMAKER . . . provides additional room for adjacent equipment without sacrificing strength.

DELIVERY OFF THE SHELF!

You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift operations. Off-shelf delivery in 64,000 combinations!

NEW LITERATURE—Send today for new Catalog SM56 with complete engineering details on Spacemaker line. Write The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
DIVERTORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHERS

CHEMLON... *the Teflon* solution to your*

hydraulic cylinder packing problems

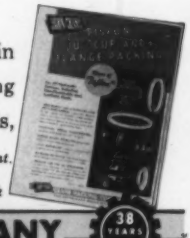
lasts longer in all hydraulic services including non-flammable and synthetic fluids

Once and for all . . . John Crane Chemlon Piston Cup, U-Cup and Flange Packings are the answer to handling *all* types of hydraulic fluids. Molded from chemically inert Teflon, they give positive sealing and long-lasting performance not possible with leather, fabric-reinforced or similar packings.

Heat will not cause these packings to shrink away from the cylinder walls or rod. They will not harden, shrink, swell or in any way disintegrate under higher temperatures often encountered in hydraulic service. Their exceptional thermal characteristics provide an operating range from −94°F. to +350°F.

Here . . . in a wide range of sizes or fabricated to your individual specifications . . . is a complete line of hydraulic packings to meet the need of any operating requirement.

Write to "John Crane" Send now for bulletin giving full technical and application data. Crane Packing Company, 6425 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*



*DuPont Trademark

JOHN CRANE **CRANE PACKING COMPANY** 38 YEARS INDUSTRIAL PROGRESS

OFFICES IN ALL PRINCIPAL CITIES

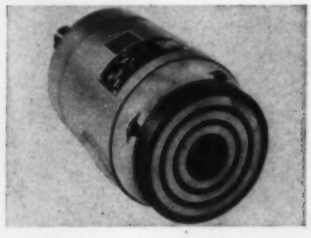
New Parts

ductor is well protected against shock and vibration, resulting in long life. **Mutual Electronic Industries Corp.**, United Cable Div., 85 Beechwood Ave., New Rochelle, N. Y.

Circle 657 on page 19

Collector Ring

resin-bonded unit has 100-amp capacity



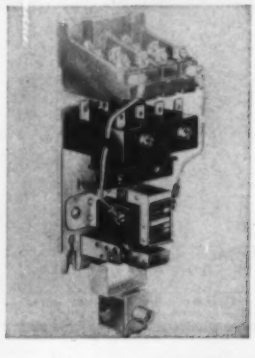
New type collector ring utilizes resin bonding, which eliminates need for screw fastening and provides an unbroken backing-plate surface. The method reduces collector-ring weight and thickness. Size range is 3 1/16 in. to 5 in. OD; capacity is 15 to 100 amp. **B. A. Wesche Electric Co.**, 1622 Vine St., Cincinnati 10, O.

Circle 658 on page 19

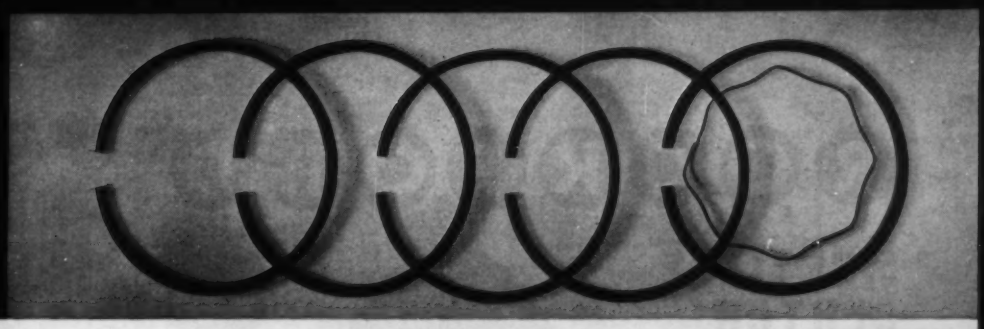
Relays

versatile units in sizes 0 and 00

Size 0 and 00 relays are for machine tool control applications. Size 00 is rated at 10 amp, 600 v ac, and size 0 at 15 amp, 600 v ac. They are available in fixed multiple pole and interchangeable multiple pole types. Both types are supplied with 2, 3, 4, 6 or 8 poles. Contactors can be wired using conventional screw-clamp terminals or optional plug-in recep-



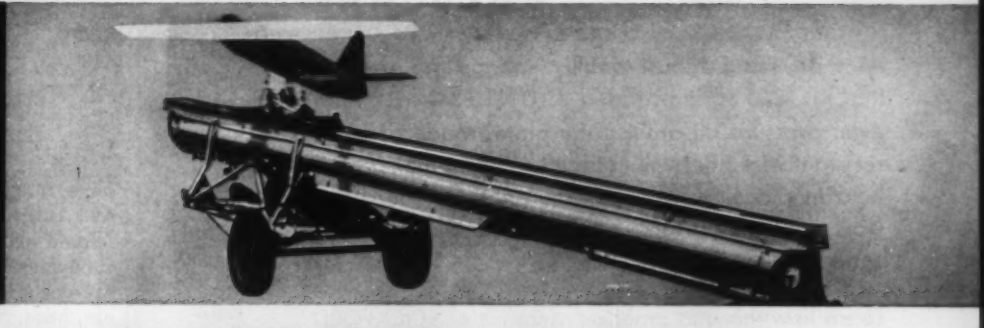
1. Do you recognize the value of these 5 rings?



2. What should a compressor have in common with this freight train?

3. It operates with no impact. Can you name the part?

4. What "fires" this Navy target drone?



WHAT'S YOUR C.Q.? (COMPRESSOR QUOTIENT)

1. You recognize these as being compressor piston rings. But perhaps you didn't know that the number isn't always the same. Many manufacturers, for example, use only four rings. Worthington, however, uses five rings – three compression and two oil. For lower oil consumption, less contamination and higher efficiency, learn to recognize the value of these five rings.

2. To cut maintenance costs, railroads are switching to "roller freight." You'll find tapered roller bearings in all Worthington compressors. Not only do they provide lower friction load, but they also can be adjusted to compensate for wear. To get the best make sure you always specify compressors with "adjustable tapered roller bearings."

3. When operating, the valve strip shown above opens and closes with a gentle rolling contact – there's no destructive impact. Replacement is infrequent and unlike many other makes which require replacement of the complete cylinder or head, all Worthington compressors are equipped with individually replaceable valves, valve guards, and valve seats. This feature saves many maintenance dollars.

4. Developed by Van Zelm Associates of Baltimore, the Navy's new mobile catapult is "fired" by compressed air supplied by a 20-hp Worthington compressor. As true in industry as it is in defense whenever men need reliable compressed air they turn to the company with a reputation for performance. Worthington Corporation, Harrison, New Jersey.

PC. 7.13

WORTHINGTON

Circle 486 on page 19

ROCKFORD

MULTIPLE CLUTCH SPRINGS

ASSURE EVEN PRESSURE

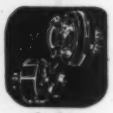
Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center


Light Over Center

Power Take-Offs

Speed Reducers

As many as 24 best quality springs are used in ROCKFORD Spring-Loaded CLUTCHES—to assure even pressure all around the plate. Made of heat-resistant wire (that will not take a "set") the springs, held in place by specially designed retainers and washers, provide long service life in today's high-speed engine driven vehicles.

Learn how this and other advantages of ROCKFORD CLUTCHES will improve the operation of *your* mobile products.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ENGINEERING B-W PRODUCTION

CLUTCHES

New Parts

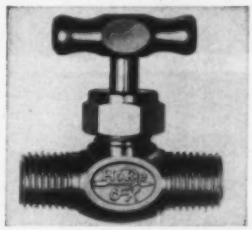
tacle. Latching attachment, which can be added to standard relay, permits quick conversion to a latching-type relay for use in memory, continuous duty and similar circuits. Construction provides fast, easy inspection or replacement of coil and magnet. Design also features exposable magnet pile faces, self-contained contact cage, and compact size. **Arrow-Hart & Hegeman Electric Co.**, 103 Hawthorn St., Hartford 6, Conn.

Circle 659 on page 19

Needle Valves

for use to 200 psi
have O-ring stem seal

Small forged-brass needle valves in both angle and straight pattern employ an O-ring stem seal which eliminates packing leaks and adjustments and can be helium-leak tested for noncritical high-vacuum service. Either vee-point or blunt-point stem is available. Bodies



have integral bonnet construction and withstand 2000 psi. Male or female pipe thread or Swagelok tube ends are available. The valves are designed for use in instrument air lines, test panels, pilot-plant installations and graphic panel boards. **Hoke Inc.**, 191 S. Dean St., Englewood, N. J.

Circle 660 on page 19

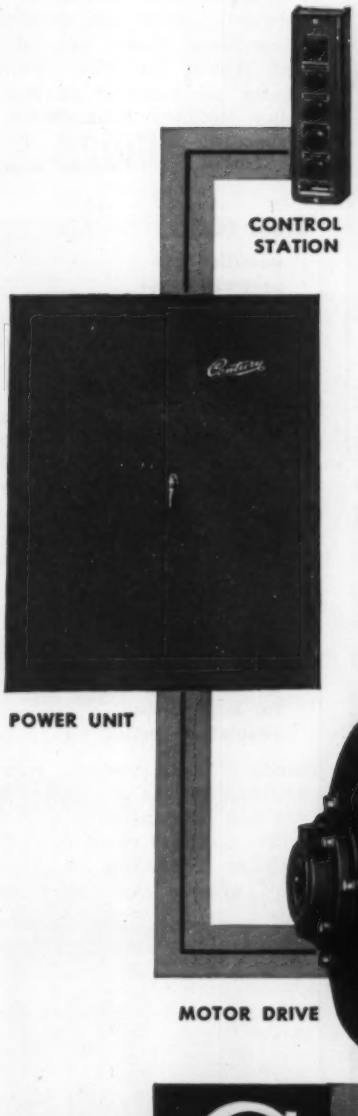
Torque Converter

for small equipment
of 15 to 30 hp

Hydraulic three-element, torque-converter drive transmission is for use in powered equipment with horsepower from 15 to 30. Transmission can be matched to various air-cooled and liquid-cooled engines and is designed for simplified coupling to engine and final drive. Directional change is accomplished

Your customers may need this drive...

TO AUTOMATE YOUR MOTOR DRIVEN PRODUCTS...
GIVE THEM PRECISE, VARIABLE SPEED CONTROL...



Century Performance-Rated°

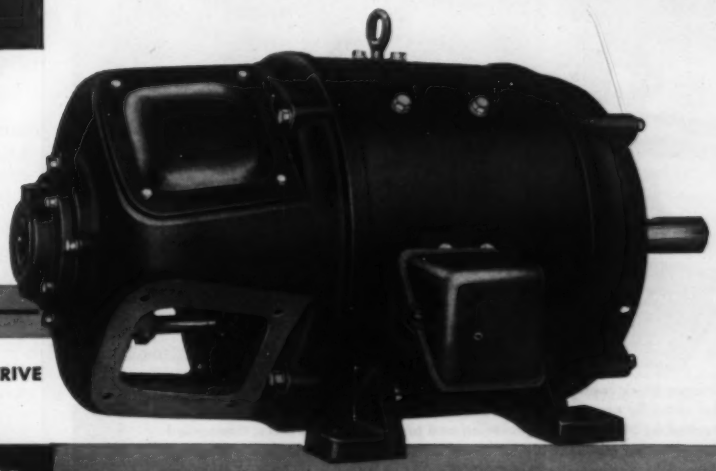
SELECTIVE SPEED DRIVE

How many of your customers could use the *full* potential of your product when given automatic operation by a Century Selective Speed Drive? Possibly more than you think.

Here's why. Predetermined, *automatic* manufacturing operations are faster, more accurate than manually controlled operations. A Century Selective Speed Drive on your product will respond to changes in operations—such as varying temperature, pressure, size, viscosity—and *automatically* adjust motor speed to fit the job.

Operating from AC, these drives offer a broad range of DC stepless speed control. They can regulate speed for individual drives or for precision interlocked multi-motor drives . . . can be used for jogging, normal or fast starts and stops, forward or reversing . . . and respond to a wide variety of remote control devices.

Century has more than 50 years' experience in engineering DC motors. For information on any motor application, call or write your nearby Century District Sales Office or Authorized Distributor.



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Performance-Rated° MOTORS 1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

One Source for ALL Work-Holding Needs

• • •

TOGGLE CLAMPS

39 TYPES and SIZES

WESPO

Featuring REAMED HOLES, for better bearing — HARDENED BUSHINGS—SERRATED to prevent turning — HIGH TENSILE STRENGTH RIVETS for longer service.

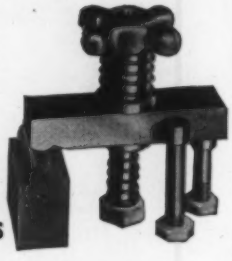
NEW — TOGGLE PLIERS

Movement of Trigger in either direction, releases pressure on Plier.

FIXTURE CLAMPS

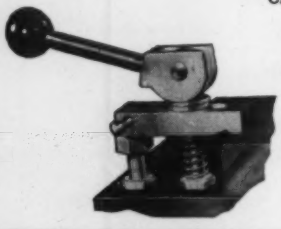
16 STYLES—159 SIZES

WESPO fixture clamp assemblies save up to 70 percent on your own designing and machining. They are standard with leading manufacturers.



NEW — SWINGLOCK CLAMP

Fastest Hand Operated Clamp Available.



COMPONENTS

1000 TYPES AND SIZES

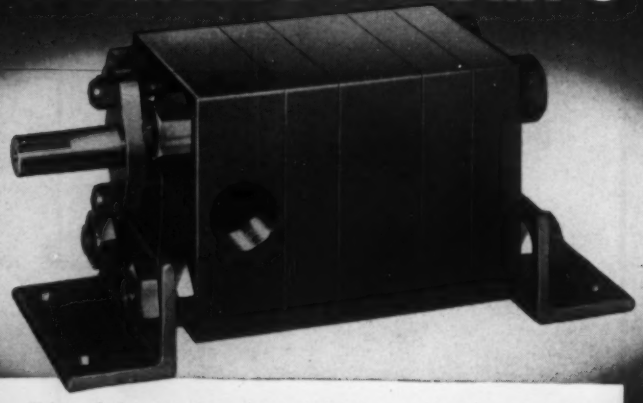
Write for Catalogs

WEST POINT MFG. CO.

26941 W. 7 Mile Road • Detroit 19, Michigan

Circle 489 on page 19

NORTHERN NITRALLOY PUMPS



Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 PSI. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

NORTHERN ORDNANCE, INCORPORATED

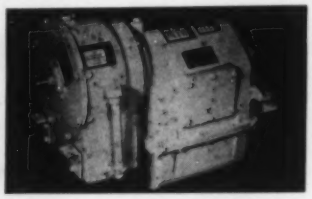
Subsidiary

NORTHERN PUMP COMPANY

MINNEAPOLIS 21, MINN.

Circle 490 on page 19

New Parts



by a dual multiple-disk clutch arrangement controlled by a single forward, neutral and reverse position lever. Gears are cut steel and shaved for quiet operation. Shafts are mounted on ball and roller bearings. **Prime-Mover Co.**, Muscatine, Ia.

Circle 661 on page 19

Brass Coating

passifies and protects brass

Brasslyfe, an air-dry spray material, passifies brass and prevents tarnishing and finger stains. It is a hard, durable coating that shows excellent weather and humidity resistance. It is sprayed, dipped or brushed, and while chemical reactions continue for several days, parts can be packaged within one hour after application. **Logo Inc.**, 12933 S. Stony Island Ave., Chicago 33, Ill.

Circle 662 on page 19

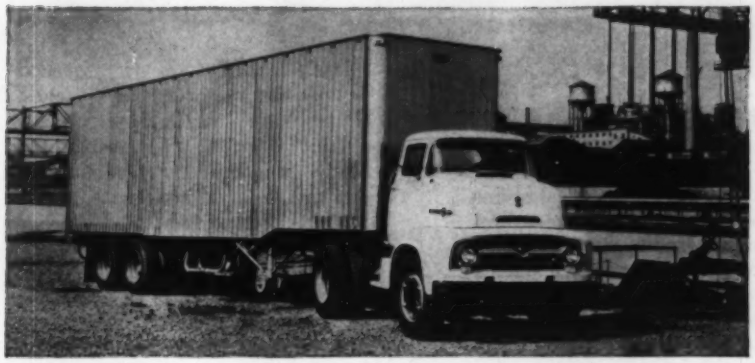
Vacuum Regulator

for high altitude simulation testing

Model VH-20 vacuum regulator has applications in aircraft industry and government test facilities where accurate simulation of high altitude conditions is required. Unit affords extremely accurate

control of vacuum in low capacity systems; it is capable of holding vacuum as low as 1 in. ±.05 in. mercury. Of forged brass and

Rolling up the Miles



Rolling Down the Costs

Ask any user: stainless steel trailers *do* roll up extra miles. In fact, they can roll indefinitely because of their great strength and resistance to rust and wear . . . qualities in which *no other metal* matches stainless steel. Of course, that longer operational life means lower over-all expense.

But stainless helps roll down the costs (and UP the profits!) in other ways. It's so strong that thin-wall sections and structural members can be used, permitting greater payload capacity and offering additional savings in operating expenses. Painting isn't needed, and maintenance is cut to a whisper.

Such properties make stainless steel an ideal material for trailers, trains, planes, etc. They qualify it for myriad other applications, too. Chances are that *you* could use it when your product (or process equipment) requires superior strength, corrosion resistance, heat resistance, sanitary qualities, ease of fabrication, durability and attractiveness. ● We'd be pleased to discuss it with you—anytime you say or anywhere you'd like to meet. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

Write for your copy of
"STAINLESS STEEL IN PRODUCT DESIGN"

40 pages of useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, adds benefits, helps sales.

ADDRESS DEPT. MD-88

WSW 6042 B

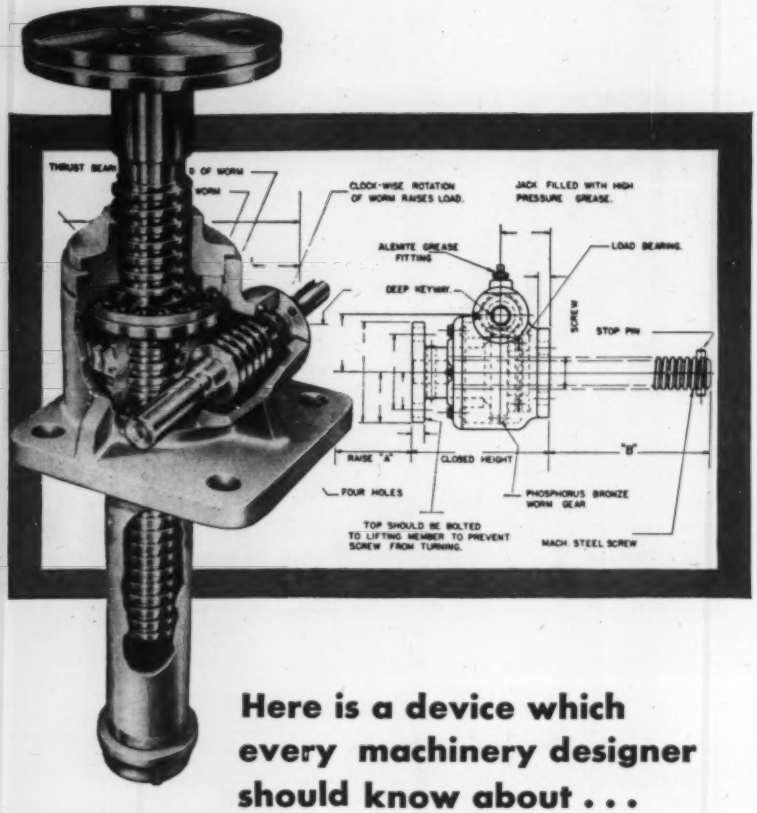
Make it BETTER-and LONGER LASTING-with

AL Stainless Steel

AL ALLEGHENY LUDLUM

Warehouse stocks carried by all Ryerson Steel plants

Circle 491 on page 19



Here is a device which every machinery designer should know about . . .

DUFF-NORTON WORM GEAR JACKS

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. They will operate in any position, and functioning as components of machinery and equipment they can raise and lower loads, apply pressure or resist impact. Jack capacities range from five to 50 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200°F.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, arbor presses, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting bulletin AD-34-V, which includes drawings and full specifications.

DUFF-NORTON **Duff-Norton Jacks**

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION: Danville, Illinois

Rachet Jacks, Screw Jacks, Hydraulic Jacks, Special Worm Gear Jacks, Rachet Hoists, Electric Hoists, Load Binders, Spur Gear Hoists

New Parts

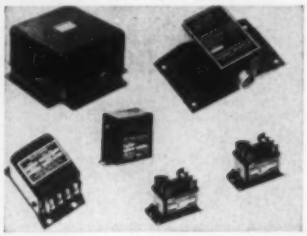
stainless steel construction, it is available in ¼-in. size. **Conoflow Corp.**, 2100 Arch St., Philadelphia 3, Pa.

Circle 663 on page 19

Miniature Flashers

meet all applicable military specifications

Miniaturized electronic flashers meet requirements of vibration, shock, temperature stability and radio noise suppression, and qualify for all applicable military specifications. RC oscillator circuits in



the flasher offer significant performance advantages over thermal devices and motor-driven switches. Units have excellent frequency stability over 14 to 30-v range, are easily temperature compensated and are maintenance-free. Output contact arrangement and flasher circuit is adapted readily to any warning system. Standard units are available with or without radio noise suppression. **Electronic Specialty Co.**, 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle 664 on page 19

Flexible Conduit

is covered with vinyl plastic sheath

Type XL liquid-tight Flex-Seal flexible electrical conduit consists of a flexible galvanized-steel conduit with copper bonding strip wound spirally in spaces between convolutions, and covered with an extruded vinyl-plastic sheath. It is also available in Type EX, without bonding strip. Plastic jacket withstands deterioration of coolants,

RESULT: Better Finish at Lower Cost

In addition to the long recognized advantages of Eaton Permanent Mold Gray Iron Castings, the use of shell coring gives an even greater uniformity of structure and an improvement in internal surface finish. This results in machining economy and fewer rejections, which, in the end, mean lower cost of finished parts.

If you have applications where more than ordinary quality is required, Eaton Permanent Mold Gray Iron Castings offer many advantages. Whatever your requirements, our engineers will be happy to work with you.

Send for Illustrated Descriptive Literature

Consider these Important Advantages

- ★ Intricately cored sections
- ★ Uniformity of castings
- ★ Higher machining feeds and speeds
- ★ Substantially increased tool life
- ★ Dense, non-porous, homogeneous structure
- ★ Freedom from inclusions
- ★ Excellent tensile strength
- ★ Ability to take high surface finishes
- ★ Freedom from leakage under pressure

EATON

FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN

Let us take over your inventory problem!

Immediate Delivery

ANY BORE SIZE • ANY MOUNT • ANY STROKE

CARTER CYLINDERS

Sounds too good to be true, but here's real help for engineers and designers who need fast action on cylinders. Carter's exclusive key type locking design and simplicity of parts *makes it possible to ship cylinder orders in 24 hours or less!* Now you can have rugged, dependable, compact quality cylinders when you want them. We produce around the clock. Your order is in process *minutes after we get it.*

Service on spare parts is good too! Experienced engineers and parts stocks are located in 40 different locations in the U. S., Canada and Mexico.

PHONE SERVICE 24 HOURS A DAY

Orders taken day or night. If you need fast service call your Carter representative or the plant. LANSING, ILLINOIS, GRanite 4-3305 or CHICAGO, BAyport 1-7186. Teletype LNSG, ILL 1119X

Complete Catalog File!

Complete bound file with ordering details for: Air Cylinders; 750 Lb. Hydraulic; 1500 Lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Type Cylinders. Complete with parts data, specifications and prices. Send today!

CARTER CONTROLS INCORPORATED

2914 Bernice Road • Lansing, Illinois (Chicago Suburb)

AIR CYLINDERS • HYDRAULIC CYLINDERS • AIR VALVES

ROTARY ACTUATORS • SPECIAL CONTROLS

New Parts

moisture, fats, corrosive fumes, chemicals and salt air. Unit has applications where electrical wiring is subject to severe adverse conditions. Flexibility and small bend radii permit use of small diameter U-bends and enable conduit to hug contours of any installation. Conduit is available in sizes from $\frac{3}{8}$ to 2 in. **Columbia Cable & Electric Corp.**, 255 Chestnut, Brooklyn, N. Y.

Circle 665 on page 19

Rotary-Vane Pumps

have capacities of 35 to 275 gph

Rotary vane-type positive displacement pumps for corrosive liquids have capacities of 35 to 275 gph, pressures to 300 psi and suction lift, 28 in. of mercury. Pumps are suitable for fluids at 375 F and are adapted for water, fuel oil, hydraulic oil, gasoline, detergents, insecticides and many chemicals, including ammonia. They are available with bronze, stainless steel, or aluminum bodies and shafts and with carbon-graphite rotary vanes. **Procon Pump & Engineering Co.**, 12721 Capital Ave., Oak Park, Mich.

Circle 666 on page 19

Digital Display Unit

utilizes single viewing screen

In-line digital display unit features a projection system which displays numbers and/or characters on a single, one-plane viewing screen. Numbers are of uniform size and intensity, insuring excellent readability from any viewing angle. Digits 0 to 9 are $1\frac{1}{4}$ in. high and include shifting decimal point. Units are available with plus or minus and ac and dc characters. Displays are available in single units and in groups. Size of viewing screen is $1\frac{9}{16}$ in. wide by 2 in. high. Voltage is 6 to 7.5, ac or

Two at a time...

Wastebaskets molded for higher production... lower cost

A major manufacturer of metal housewares decided to broaden his line by adding plastic wastebaskets. His first step was to call in a Nosco sales-engineer . . . logical, because Nosco men are qualified plastic-parts technicians who know exactly how to put Nosco engineering and production facilities to work. The Nosco plant thus becomes the customer's own plastic molding department!

For the 8-quart basket, Nosco engineered *the deepest two-cavity mold ever built*. This hot-runner mold, which virtually eliminates all scrap, weighs more than a ton and is run in one of Nosco's large pre-plasticized presses.

The two larger size wastebaskets, pictured above, are now molded one at a time, but when production warrants, these parts can also be molded in two-cavity dies.

Nosco "Can Do" enabled this manufacturer to successfully produce deep-drawn parts at lower cost. Why not let one of our sales engineers put Nosco "Can Do" to work in designing your next plastic part? Please write.

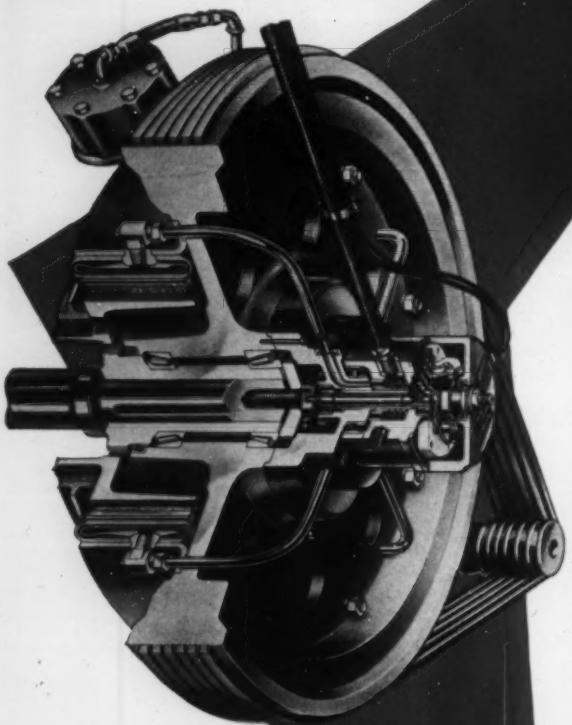
NOSCO plastics, inc. • erie 2, pa.

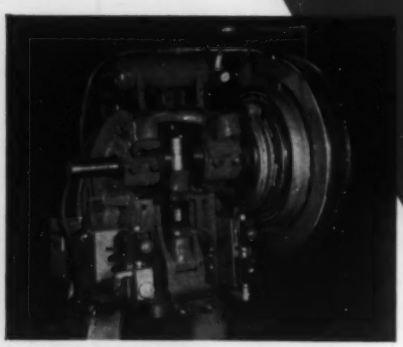
World's largest injection molding plant

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

FSPA*

wins enthusiastic acceptance from press industry!





Typical illustration showing Fawick Standardized Press Application on a 30 Ton O.B.I. Press.

* **FAWICK STANDARDIZED PRESS APPLICATIONS** have earned the acclaim of press builders and users all over the country. As original equipment on new presses or for field conversion of old presses to modern air operation, FSPA assures maximum production throughout the life of the press.

WITH FAWICK FSPA YOU GET . . .

MAXIMUM PRESS SPEED: FSPA components are designed to increase the operating speed of your press efficiently and safely. The Fawick CB Airflex Clutch and CS Brake assure full operating power and positive braking action. The Timing Rotorseal and High-Speed Clutch Controls provide accurate cycle-timing and precise control of press operation.

MAXIMUM PROTECTION TO PRESS, DIES AND OPERATOR: Immediate and complete response of clutch and brake protects press equipment and operator in case of accidental tripping or other emergency. Air-released, spring-engaged brake assures dependable braking during electrical or air failure. Overload protection is provided through pre-selected clutch air-pressure. Quiet, positive cushioned action of clutch actuating tube cuts worker fatigue and reduces noise.

ADAPTABLE TO ANY TYPE OPERATION: Knurled knob on Fawick Timing Rotorseal provides quick, simple, cycle-timing adjustment . . . no old-style, bulky cycle-timing chains, sprockets or guards are required. High-Speed Clutch Controls provide single stroke, continuous, timed-inching, hand-foot, semi-continuous, "long" or "short" operation as needed.

SIMPLIFIED INSTALLATION: Complete package units including dimensional drawing, wiring diagram and installation instructions are provided with each FSPA application. Installation requires simple machining of crankshaft or backshaft to provide proper length, diameter and keyway. In a few hours, FSPA can be installed on your press in your own plant.

Equip your machinery for modern high-speed pneumatic operation with FSPA. For more information, call or write Fawick today.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

Circle 496 on page 19

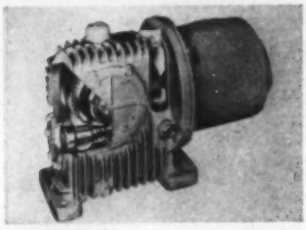
dc. **Industrial Electronic Engineers,** 3973 Lankershim Blvd., North Hollywood, Calif.

Circle 667 on page 19

Worm Gearmotors

have long-life double-enveloping worms

Compactness, high-capacity and long life are provided by double-enveloping worm gearing in line of right-angle worm gearmotors. Units are available with or without motors, as desired. Four different sizes are available from fractional to 40 hp. Both extended-shaft and shaft-mounted models



are available in 28 standard output speeds from 6.25 to 525 rpm. **Michigan Tool Co.,** Cone-Drive Gear Div., 7171 E. McNichols Rd., Detroit 21, Mich.

Circle 668 on page 19

Magnetic Cores

operate from −60 to 125 C

Hipermag magnetic cores are for use in magnetic amplifier reactors, transductors, current transformers and other magnetic devices where high gain and high sensitivity are required. Cores are toroids wound with 1, 2 and 4-mil thick iron-nickel alloy with high degree of crystal orientation. When high degree of shock resistance is re-

(*Continued on Page* 170)

This quick demonstration at your desk will show how to get superior, more economical fastening with TOWNSEND LOCKBOLTS*

In a few minutes we can show how Townsend lockbolts will give you superior fastening at lower installed cost and improve your products. A Townsend engineer will demonstrate the ease with which they can be installed, and prove their high resistance to vibration and shock.

Townsend lockbolts provide a higher clinch, or clamping action than rivets, and more uniform fastening than nuts and bolts. They fill the hole better than other fasteners, have high tensile pre-load, make a more rigid joint and provide an effective liquid seal. Available in both steel and aluminum alloy in a variety of diameters and lengths—two head styles.

For a demonstration of how Townsend lockbolts will improve your fastening while lowering the cost, write to Townsend Company, P.O. Box 237-E, New Brighton, Pa.

*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

See Lockbolts Demonstrated At The Design Engineering Show—Booth 1139

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

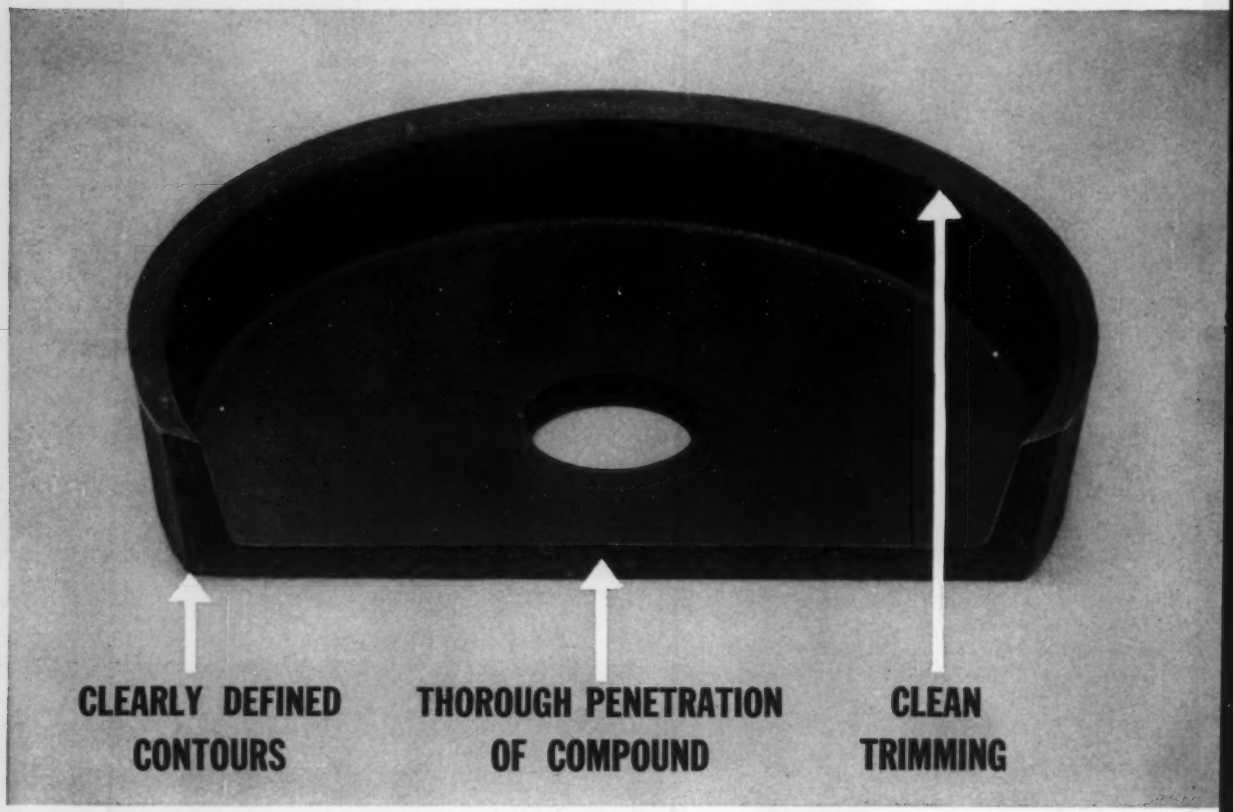
NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Canada: Toronto • Export: New York, U.S.A.

Circle 497 on page 19

CALL ON R/M ENGINEERING SERVICE



MAKE THIS TEST AND SEE WHY R/M FABRIC PISTON CUPS ARE SO LONG WEARING

Cut into an R/M Fabric Piston Cup and you will see how R/M's special impregnation method results in deep, thorough penetration of the compound into the fabric. This keeps wicking action from attacking the cup internally and gives superior resistance to ply delamination. The result is extra performance and longer wear.

Another feature you notice immediately about R/M Fabric Piston Cups is their clean outward appearance. Clearly defined contours, smooth surfaces, and precision trimming all show superior molding practice.

Equally important, R/M's careful quality control assures dimensional uniformity, consistent hardness, and strict adherence to industry standard sizes.

R/M Fabric Piston Cups are available to fit hydraulic and pneumatic cylinders of from ½ to 12 in. diameter. Cups are furnished in varying degrees of hardness for pressures up to 1500 psi and in different compounds to meet specific operating conditions.

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

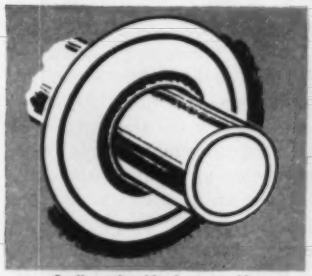
Abrasive and Diamond Wheels

Industrial Drive Belts

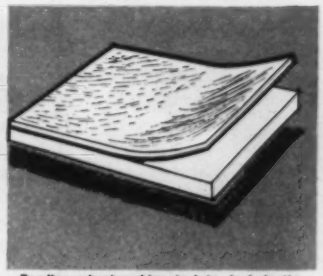
Industrial and Automotive Hose

Conveyor Belts

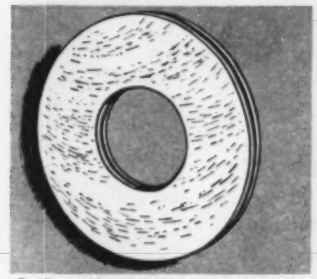
FOR HELP IN SOLVING YOUR PROBLEMS



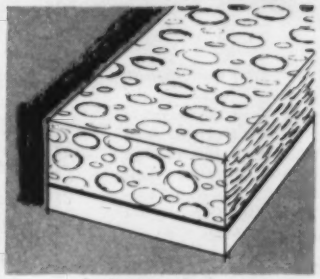
Sealing solenoid valve assembly



Bonding asbestos shim stock to vinyl plastic



Bonding semi-metallic facings to steel plates



Bonding sponge to steel

R/M Ray-BOND® ADHESIVES
simplify product design, cut costs

R/M adhesives, protective coatings, and sealers extend the horizons in the design of new products of all kinds. As in the products shown here—and in countless other applications—they bond parts together, help build stronger, more durable assemblies and, in addition, help reduce production costs.

R/M Ray-BOND adhesives, compounded of synthetic or natural rubber, resin bases of many types, and combinations of rubber and resins, have excellent bonding qualities and great resistance to heat. They are suitable for bonding diverse materials such as wood, glass, cork, plastics (including "Teflon"*), friction materials, metals and countless others. They resist temperature extremes ranging from −80°F to 700°F.

*A Du Pont trademark

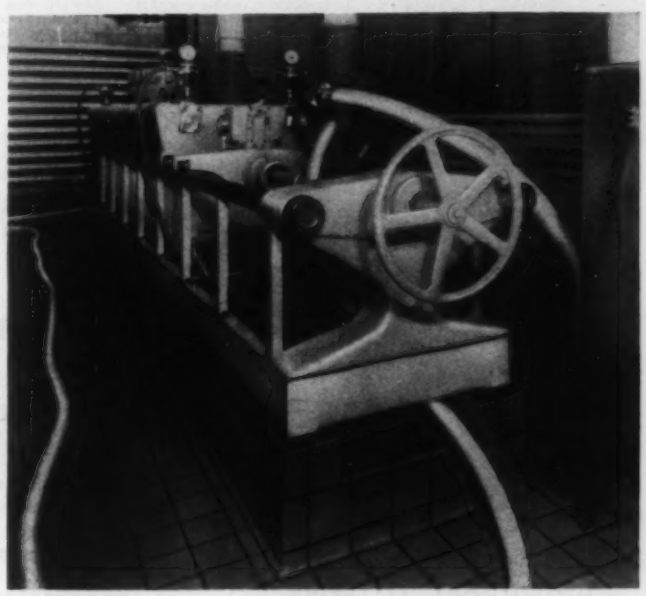
For booklet shown, or other data, write, wire or phone:

Adhesives Department
RAYBESTOS-MANHATTAN, INC.
Bridgeport, Conn.

ENGINEERED RUBBER HOSE

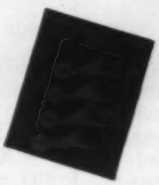
R/M makes rubber hose for *every* application. Usually one of the R/M exclusive constructions will fill your requirements. Homoflex is a lightweight, easy handling hose with rope-like flexibility—ideal for use with air tools and water. Allflex is a versatile all-purpose hose for handling air, water, oil, gases and mild chemicals. If you need special constructions, R/M makes them all . . . for acids, chlorine, sandblast or contaminating chemicals. Special burst-resisting types with flexible wire insertion are made for safer service with high pressure air and steam. If you have metal piping wear, corrosion or expansion problems, use Condor Flexible Rubber Pipe or Manhattan Expansion Joints. Whether your design calls for hose, transmission or conveyor belts, V-belts, Poly-V* Drives, or molded rubber products, you can depend on R/M.

*Poly-V is a registered Raybestos-Manhattan trademark



For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J. • GRegory 3-2000



RAYBESTOS-MANHATTAN, INC.

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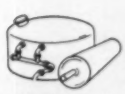


Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

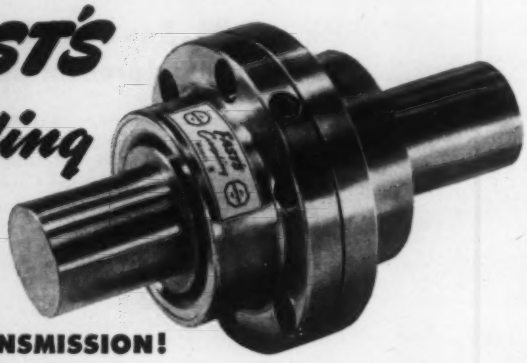
Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

Circle 498 on page 19

The incomparable Model B

FAST'S Coupling



LOW-COST POWER TRANSMISSION!

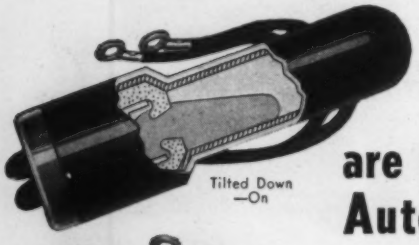
Designed for light and medium drives—fans, blowers, pumps—a lighter, smaller and lower priced Fast's Coupling! The same famous features found in all Fast's Couplings . . . the same mechanical flexibility, the same positive lubricating principle, the same rugged construction and trouble-free performance . . . the same highly efficient power transmission which has made Fast's Couplings the leader for more than 30 years! Available for shaft sizes up to 2⅞" and sold with Koppers' free engineering service. For the low-cost solution to your shaft coupling problem, write: Koppers Company, Inc., *Fast's Coupling Dept.*, 3504 Scott Street, Baltimore 3, Md.

THE ORIGINAL

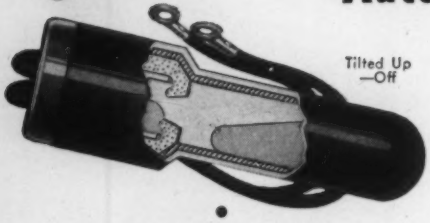
KOPPERS **FAST'S Couplings**

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus. *Engineered* Products Sold with *Service*.

Circle 499 on page 19



DURAKOOL Tilt Switches are the Life of your Automatic Controls



MILLIONS OF CYCLES WITHOUT FALTERING

This steel-clad Durakool mercury tilt switch has unique construction features that deliver years of trouble-free performance on the most difficult assignments you can find. Operating under sealed-in, pressurized hydrogen gas, it takes 24 hours, fast cycling schedules in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

See telephone directory for local distributor, or write.

DURAKOOL, INC.

ELKHART, INDIANA, U.S.A.

700 WESTON RD., TORONTO 9, CANADA

Durakool ALL-STEEL MERCURY *Switches*

New Parts

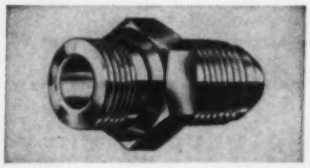
(*Continued from Page* 167)

quired, or when unit is to be encapsulated or resin cast, cores are hermetically sealed in nylon or aluminum case and filled with silicone oil. Cores are also furnished in nylon or aluminum case with silicone grease as damping medium. Nylon cases are temperature stable from −60 to 125 C. Cores are available in sizes from ⅝ to 4 in. ID, ¾ to 5¼ in. OD, and 3/16 to 2 in. high. Weight is from 2.80 to 2010.0 gram. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

Circle 669 on page 19

Straight Fitting

for straight-thread installation



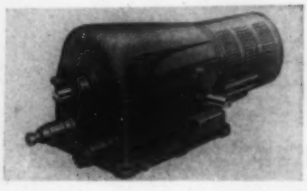
CN straight adaptor shape fitting is designed for positive leakproof sealing of all types of hydraulic fluids without use of O-rings. Wedging action of metal seal ring, which acts as both gasket and lock washer, provides resistance to heat and vibration. Fitting is available in a wide range of standard shapes and sizes for any application. **L & L Mfg. Co.**, 8088 E. Nine Mile Rd., Van Dyke, Mich.

Circle 670 on page 19

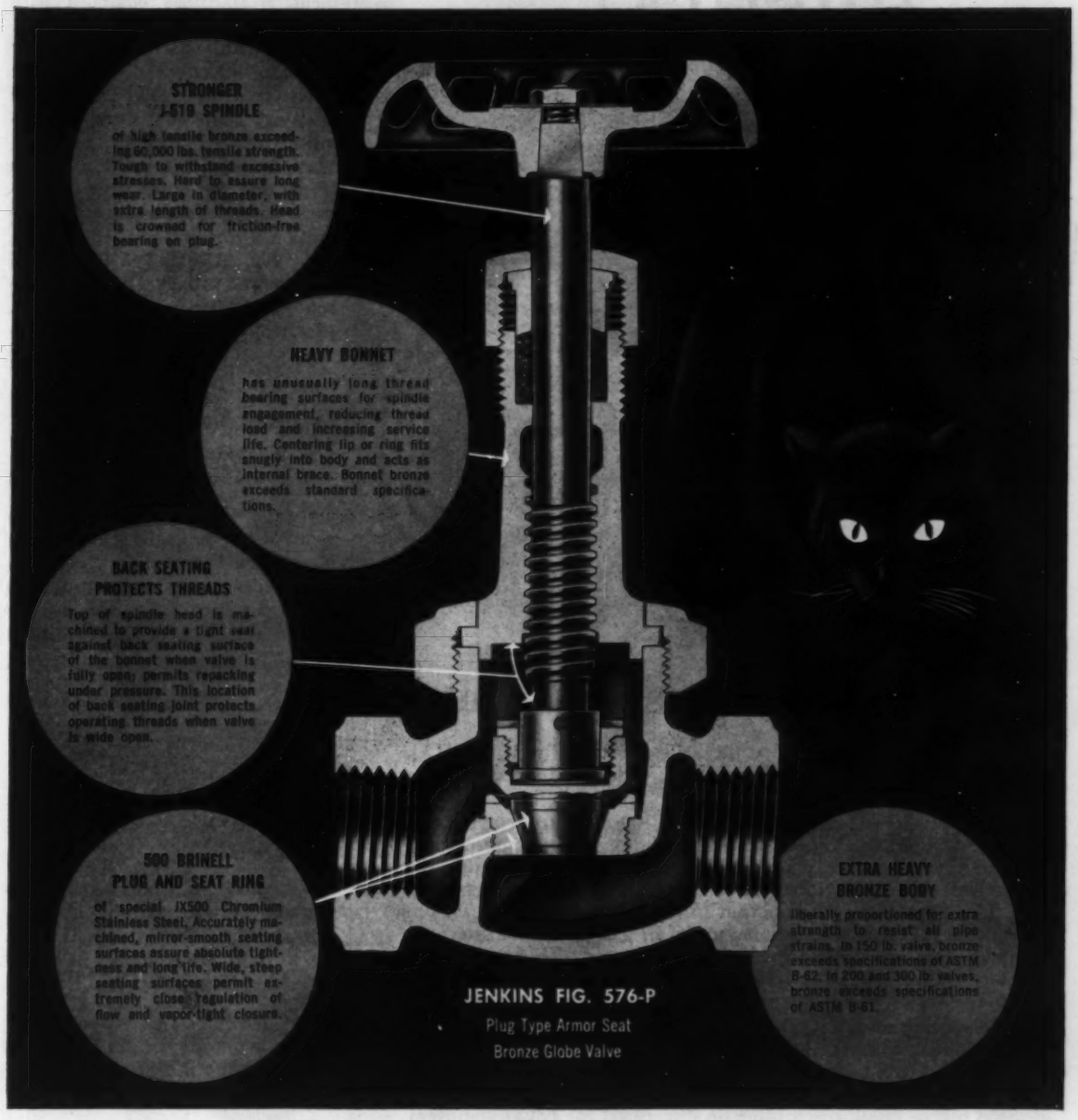
Gear Drive

differential unit is hydraulically regulated

Hydraulically regulated differential gear drive provides synchronous speed regulation and precise draw adjustment, obtained through a hydraulic motor differential cage drive and hydraulic tachometer-motor feedback-control arrange-



Where valves need 9 lives...


STRONGER I-STD SPINDLE
of high tensile bronze exceeding 60,000 lbs. tensile strength. Tough to withstand excessive stresses. Hard to assure long wear. Large in diameter, with extra length of threads. Head is crowned for friction-free bearing on plug.
HEAVY BONNET
has unusually long thread bearing surfaces for spindle engagement, reducing thread load and increasing service life. Centering lip or ring fits snugly into body and acts as internal brace. Bonnet bronze exceeds standard specifications.
BACK SEATING PROTECTS THREADS
Top of spindle head is machined to provide a tight seal against back seating surface of the bonnet when valve is fully open; permits repacking under pressure. This location of back seating joint protects operating threads when valve is wide open.
500 BRINELL PLUG AND SEAT RING
of special JX500 Chromium Stainless Steel. Accurately machined, mirror-smooth seating surfaces assure absolute tightness and long life. Wide, steep seating surfaces permit extremely close regulation of flow and vapor-tight closure.
EXTRA HEAVY BRONZE BODY
liberally proportioned for extra strength to resist all pipe strains. In 150 lb. valve, bronze exceeds specifications of ASTM B-62. In 200 and 300 lb. valves, bronze exceeds specifications of ASTM B-61.
JENKINS FIG. 576-P
Plug Type Armor Seat
Bronze Globe Valve

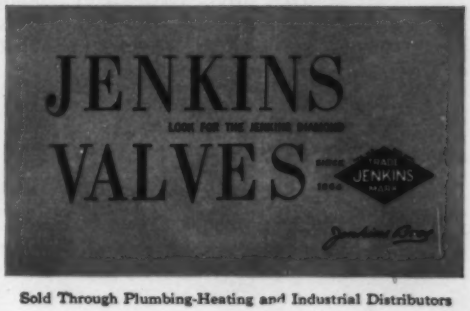
Install this JENKINS...made to defeat valve-killers

HERE are just five of the eighteen ways by which Jenkins Plug Type Valves have been engineered for maximum wear in valve-killing services. For any close-control steam service like drains, bypass lines, drips, blowoff, throttling, bleeders . . .

Or where abrasion, entrapped pipe chips, scale or rust tubercles are a problem . . .

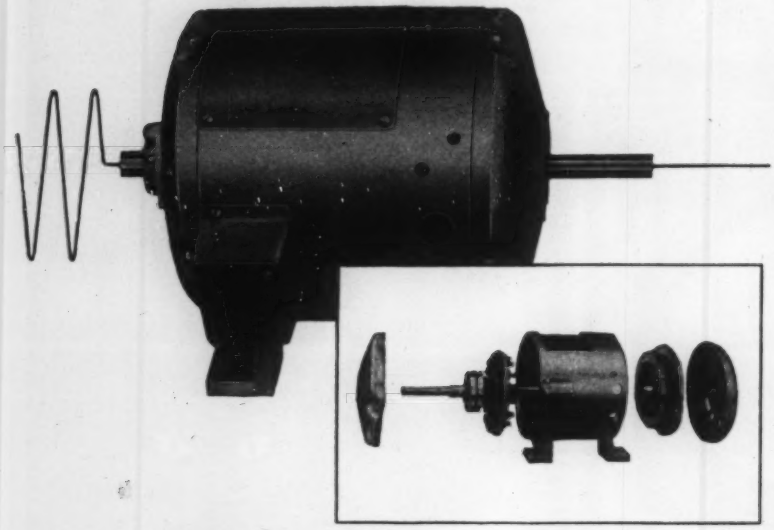
You'll cut maintenance and replacement costs by specifying *"Jenkins Plug Type, with the 500 Brinell Stainless Steel Armor Seat"*. In the Jenkins Catalog are 150 lb., 200 lb. and 300 lb., Globe and Angle, screwed or flanged end valves in a full range of sizes. And, they are available quickly from local distributors' stocks.

WRITE us, or ask your Jenkins distributor for descriptive folder No. 202-A. Jenkins Bros., 100 Park Avenue, New York 17.



Sold Through Plumbing-Heating and Industrial Distributors

SPECIAL



rotary rectifier for speed control

This is a unique, commutating device, specially built by ESCO, to provide a signal used for accurate, wide-range speed control for a variable frequency alternator.

It's a rectifier because it supplies a DC speed control current from an AC alternator output. Special windings in the alternator impress a "revolving voltage" on a fixed commutator within the device. Rotating brushes collect this voltage, in proper synchronization, to deliver a DC output through two slip rings. This output is exactly proportional to the air gap flux of the alternator and is used to control the drive motor speed. This particular method was chosen for its exceptionally smooth, accurate control over a wide speed range from well below 100 rpm to above 4,000.

This is typical of ESCO's unusual ability to design special rotary equipment to meet customer needs. Whether or not your problem is this special, remember ESCO's forty years of broad experience is always available to you. No motor or generator problem is too big or small, too routine or specialized for ESCO engineers and craftsmen.

Refer to Esco Catalog in section 4a/EL in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem . . . we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

New Parts

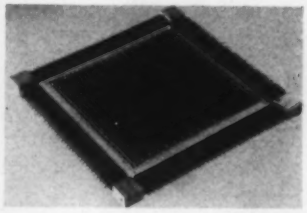
ment. Machines equipped with the drive can be inched or reversed with line shaft dead or running. Manual pushbutton or valve controls are provided for starting, stopping, draw adjustment, inching, reversing all sections, for applying brake for rapid stops, and for quick draw adjustment during machine threading operation. Drive is available in 150, 300, 600, 900 and 1200 AGMA horsepower ratings. **Black - Clawson Co.**, Paper Machine Div., Watertown, N. Y.

Circle 671 on page 19

Magnetic Memory Frames

of stacked construction in sizes through 10 × 10 in.

Magnetic memory planes are assembled individually in stacks, eliminating the need for molds, assuring rapid delivery on any size plane and eliminating the need for tool charges on production items



and prototypes. Improved design provides greater frame strength and rigidity. Frame sizes through 10 × 10 in. are available. **General Ceramics Corp.**, Keasbey, N. J.

Circle 672 on page 19

Synchronous Motor

has speeds from 60 rpm to ½ rpd

Type 114 high torque, permanent-magnet synchronous motor has torque of 30 oz-in. at 1 rpm and speeds from 60 rpm to ½ revolution per day. Applications include instrumentation and automatic controls, vending machines or any machine requiring accurate drive. Motor is provided with a variety of output shaft dimensions. Unit also incorporates instant start and stop, low input (approximately 3.25 w), and permanent lubrication. Motor operates on standard

QUALITY

ATECO · TRACTO · CATERPILLAR · Massey-Harris · DOMOR · ALGOMA · JOHN DEERE · INTERNATIONAL HARVESTER · TORO · PMCO · The OHIO RUBBER Co. · Butler Bin Company · OLIVER · A-C · CASE. · TERRATRAC · FAIRBANKS-MORSE · ROTO-SPEED

Your high grade machines deserve MECHANICS Roller Bearing UNIVERSAL JOINTS quality. You can benefit from the protection and convenience of "once-a-season" or "lifetime" lubricated MECHANICS roller bearing universal joints — and still have the economy of stamped yoke construction. Let our engineers show you how MECHANICS Roller Bearing UNIVERSAL JOINT developments will give your machines competitive advantages.

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MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner • 2032 Harrison Ave., Rockford, Ill.
Export Sales: Borg-Warner International 36 So. Wabash, Chicago 3, Illinois

MECHANICS
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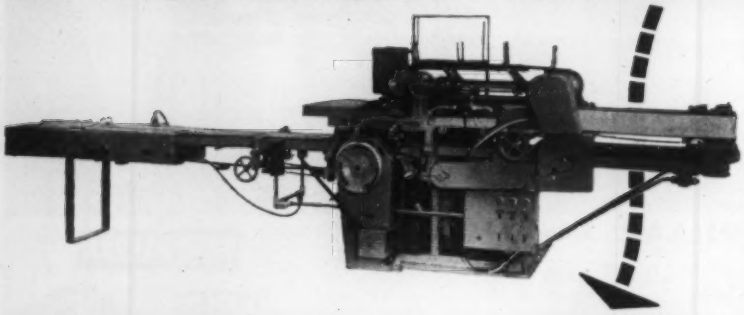
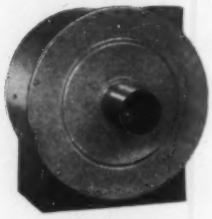
UNIVERSAL JOINTS

For Cars • Trucks • Tractors • Farm Implements • Road Machinery • Aircraft • Tanks • Busses and Industrial Equipment

Use of SPENCER Vacuum



Solved this Designer's Problem



In designing this frozen food wrapping machine, product of Package Machinery Co., the problem was to find a means of holding the easy-opening tape in proper position.

A Spencer 1/2 H.P. vacuum producer proved the answer. Vacuum holds the cellophane tape in fixed position on a perforated belt. This belt transports and applies the tape across the web feed of a wrapper (wax paper, foil or cellophane) prior to placing wrapper around the package.

If you have a design problem where vacuum might offer a solution, it will pay to check with SPENCER—manufacturers of a complete line of vacuum producers for standard or special applications.

Standard Capacities of Spencer Vacuum Producers
2 through 100 H.P.
Up to 12" Mercury Vacuum
Volumes up to 17,000 C.F.M.

Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"

Illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"

Supplies application data on Spencer Blowers. Request Bulletin 107-C.

The SPENCER TURBINE COMPANY
HARTFORD 6, CONNECTICUT

New Parts

ac voltages, 50 and 60 cycles, and is 1 5/16 in. deep. **Cramer Controls Corp.**, Centerbrook, Conn.

Circle 673 on page 19

Quartz Infrared Lamp

in lighted lengths from 5 to 50 in.

Tubular quartz infrared lamp, 3/8-in. in diameter, is available in lighted lengths from 5 to 50 in. at 100 w per inch. It has many applications, including cooking and food warming, use in office copying machines, in printing, textile and aircraft industries, and in machine shops and railroads. It bakes lacquers, enamels and varnishes in a short time. Maintenance is easy and inexpensive, and operating cost is low. Lamp is small, has

high operating temperature, and withstands acid and thermal shock. It is designed to last more than 5000 hr. **General Electric Co.**, Nela Park, Cleveland 12, O.

Circle 674 on page 19

Tubular Stainless Steel

has high strength-to-weight-ratio

Precipitation hardening stainless steel, designated 17-7PH, is available in tubular forms for applications requiring corrosion resistance, light weight and high strength. Precipitation hardening yields a Rockwell hardness of C 42-43. At this hardness, tensile strength is 200,000 psi and yield strength between 180,000 and 190,000 psi. Elongation in 2 in. is 9 per cent. Tubular forms are supplied an-

only circuit breakers
can be tested!
...and tests prove
Westinghouse AB breakers
protect at the precise rating
you need

breaker protection is *sure* and *accurate*
YOU CAN BE SURE...IF IT'S Westinghouse
J-30232

PRE-TESTED CIRCUIT PROTECTION IS "INSURANCE"

by H. D. Dorfman
Westinghouse Electric Corporation

A most important consideration in selecting a circuit protective device is its ability to protect at the precise rating for which it is designed. Under-rated devices are nearly as bad, though not as hazardous, as over-rated ones. Load testing is the only positive way to be sure a circuit is truly protected.

Obviously, fuses cannot be calibrated and load-tested. An operation-tested fuse is like a tested match, of no further use. Thus, precision protection may not be assured.

Circuit breaker accuracy can be tested by the manufacturer before shipping and retested, if desired, in the field. When tested breakers are provided by a reputable company, you can be sure they will protect at exactly the rated load.

Heat-Treating Important

A number of factors distinguish the properly designed and tested breaker. Life-long maintenance of calibration is assured by several preliminary steps. Heat-treating of bimetal subassemblies relieves any stresses set up during manufacture and insures their permanent "set." Failure to heat-treat can result in later destruction of calibration by load cycles.

Latching surfaces should be ground and polished to eliminate erratic tripping. Latch members also should be heat-treated to prevent wear and distortion. To insure perfect mating of parts, the production and assembly of circuit breakers should take place in a temperature and humidity-controlled area.

Tests Verify Calibration

These tests conducted on all Type F breakers made by my company, for instance, typify the painstaking care necessary to assure the protective quality of such devices.

1. Magnetic elements are adjusted to trip at ten times the thermal rating.

2. After pre-setting of calibrating screw, thermal elements are tested to trip the breaker at a specific overload, within strict limits.

3. Only after the second successful thermal tripping run is the cover assembled on the breaker.

4. Following a 5,000-volt insulation check, the thermal calibration is again test-verified to determine that bimetal calibrations were not altered before or during breaker cover placement.

Such tests assure positive circuit protection at the precise rating for which the circuit breaker is designed.

MIDLAND
WELDING NUTS

take seconds to apply... save hours of labor!

If you make a component part of an ultimate metal assembling operation requiring bolting in hard-to-get-at places, Midland Welding Nuts may well be the answer to simple, secure fastening later on. The practical Midland method anchors the nut in the exact location, ready to receive the bolt. There's no guesswork and cross-threading becomes impossible.

It's easy to apply Midland Welding Nuts.

Just insert the collar in the hole for bolt or screw, resistance-weld the nut in place, and the nut is anchored for the life of the job. Nuts can be automatically fed to the welder to save time.

Midland Welding Nuts assure close fit of metal parts. They can't work loose, causing annoying rattles. Also, parts can be removed easily and quickly for replacement or repair without threat of losing nuts. Assembly workers prefer them because they turn stubborn, difficult jobs into simple, easy to handle projects, often converting two-man tasks into one-man operations.

Write or phone for complete information!

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Avenue • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

AUTOMOBILE and TRUCK FRAMES • AIR and VACUUM POWER BRAKES

AIR and ELECTRO-PNEUMATIC DOOR CONTROLS

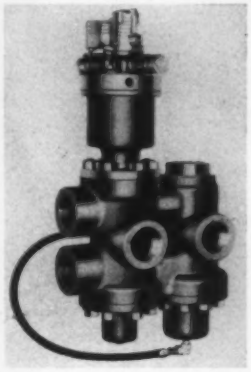
nealed to provide maximum ductility. Tubing and pipe are readily bent, formed, drawn, welded, brazed and machined. **Carpenter Steel Co.**, Alloy Tube Div., Union, N. J.

Circle 675 on page 19

Hydraulic Valve

four-way unit for 3000-psi service

E-400-X 3000-psi semiautomatic four-way hydraulic valve provides leakfree operation with water, glycol or oil-base hydraulic fluids. Designed especially for the die-casting industry, the valve will not reverse itself in case of air or electrical supply failure. Corrosion-resistant materials are used



throughout. Valve is available in 1, 1½ and 2 in. NPT sizes, for line pressures to 3000 psi. For valve actuation, 60 to 125 psi air is used. **Sinclair-Collins Valve Co.**, 454 Morgan Ave., Akron 11, Ohio.

Circle 676 on page 19

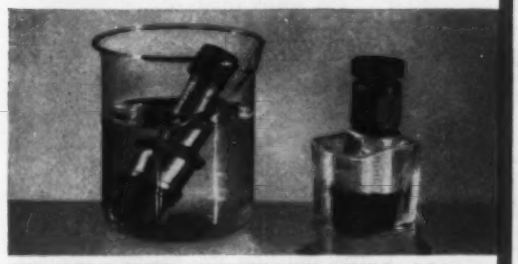
Spring-Washer Stacks

enable economical usage of long stacks

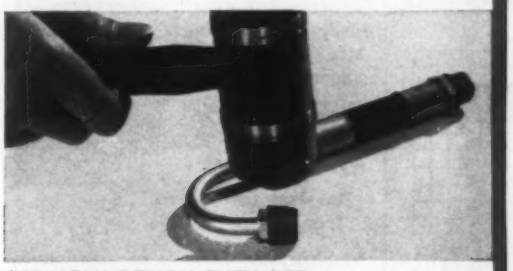
Preassembled stacks of multiple Belleville spring washers, held together by pins or rivets passing through the washers at or near their neutral axes, provide a compact unit which can be incorporated as one-piece component in the final application. Stacks are easier to handle and install than loose washers, permitting automatic assembly, and allow use of much larger stacks than are

Circle 506 on page 19

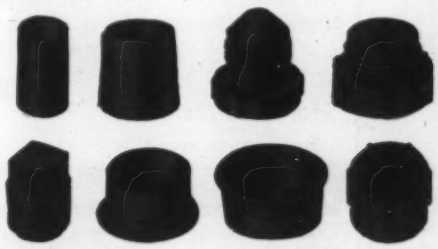
SEE HOW EASY THEY SLIP ON, AND OFF!
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Threaded styles are knurled to spin on or off with ease. Costing less to buy, they cost less to apply.



SEE HOW THEY WITHSTAND ACIDS, SOLVENTS, HEAT AND COLD . . . and keep out dust and moisture, too. Dunk a CaPlugged product in any solution. Subject it to actual process conditions and temperatures. Made of tough, flexible Polyethylene, CaPlugs are impervious to most common chemical reagents, acids and solvents . . . retain form stability under stress at temperatures from -94°F. up to 175°F.



SEE HOW TOUGH THEY ARE. For proof, drop a product on its CaPlug . . . tap it with a mallet . . . or make a trial shipment of parts with CaPlugs applied. You'll find that these versatile closures provide "kid-glove" protection and will not collapse, chip, break or shred under the most severe of conditions.



SEE HOW EASY IT IS TO GET CaPlugs THAT FIT. By mailing the coupon, you'll receive a free sample of each of the ten different styles which are available in a combined total of over 300 stock sizes. There's a CaPlug that's *right* for practically any closure need. You name it! "Off-the-shelf" deliveries from a 30,000,000 inventory can be made to answer immediate requirements promptly.

see how CaPlugs can protect your products

(IN PROCESS, TRANSIT AND STORAGE)

by testing a free sample assortment like this

YOU'RE INVITED TO TEST CaPlugs in any way you choose. The coupon below will bring a random assortment to your desk . . . plus illustrated literature, complete details and prices. Reasonable quantities of additional samples in specific sizes for testing are also yours for the asking (details in literature).

MAIL THIS COUPON FOR FREE BOX OF CAPLUGS, DETAILS AND PRICES

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
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RUSH a free assortment of CaPlugs, literature and prices to us, without obligation.

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in size
LONG...
in performance

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Look at these features:

- AC or DC Models
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- Instantaneous mechanical push-button reset

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45 West 45th Street, New York 36, N. Y.

Circle 508 on page 19

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WHITEPRINT COPYMATION

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Circle 509 on page 19

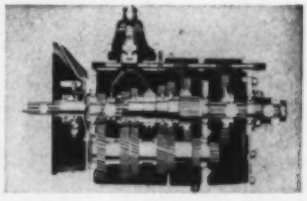
New Parts

practical with individually assembled washers. Preassembly of washers in permanent stack form also eliminates possibility of improper assembly or wrong sequence. **Associated Spring Corp.**, Bristol, Conn.

Circle 677 on page 19

Engine Transmission

has seven forward speeds and reverse



Transmission for gasoline engines up to 400 cu in. piston displacement provides driver with simple short-distance shifting. Seven forward speeds in progressive and selective steps have closely spaced and equal ratios in operating range. All forward speeds and reverse are shifted by a single lever. **Fuller Mfg. Co.**, Transmission Div., Kalamazoo, Mich.

Circle 678 on page 19

Nylon Washers

in sizes for screws from No. 4 to ¼-in.

Black nylon washers for use where dielectric and other properties of nylon are desired are available in five sizes to fit screws from No. 4 to ¼-in. Outside diameters range from 9/32 to 11/16-in. and thicknesses from 0.020 to 0.040-in. **Weckesser Co.**, 5701 Northwest Highway, Chicago 30, Ill.

Circle 679 on page 19

Gear-Head Motor

has output speed of 12.5 rpm ± 25 per cent

Miniature gear-head direct-current motor is designed for intermittent duty and is reversible. It conforms to military specifications MIL-M-8609 (ASG) and missile purchase description MPD-401. Voltage is 115 v dc ±5 v dc. Output speed is 12.5 rpm ±25 per

Steel-Weld
FABRICATION
Use WELDED STEEL
for Greater Strength
with Less Weight!
The 35-Ton Weldment above is the Center Section of a three-section Bed for a large Underdrive Press. This piece, and the units illustrated at the left, are typical of thousands of Steel-Weld Fabricated parts and assemblies produced by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. It is possible that you, too, could benefit by the economies and other advantages offered by welded steel components in your product. In any type of heavy machinery there are parts and sub-assemblies that can be produced more economically and more satisfactorily in welded steel, because, in weldments you get greater strength with less weight, plus the additional advantages of greater rigidity and predictability. Before you place an order for weldments, you will want to discuss your requirements with Mahon . . . because here is a unique source for welded steel in any form . . . a reliable and responsible source with complete facilities for design engineering, fabricating, machining and assembling . . . a source where advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or, better still, have a Mahon sales engineer call at your convenience.
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With National Seals

Quality control isn't a myth— it's a crusade!

At National, quality control is based on the oil seal industry's most rigid manufacturing specifications. It begins with critical examination of raw materials. It includes constant checking of form tools and molds. It extends to exhaustive optical examination of all seal components by an exclusive process developed at National. (In this process, seals are cast and cross-sectioned, and an optical comparator used to show exact shape and position of every seal part, mounted on the shaft or unmounted.) And always, there are extensive and continuing operating and "leak" tests of finished seals.

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Cleveland, Ohio, 210 Heights Rockefeller Bldg., YEllowstone 2-2720 • Dallas, Texas, 2520 West Mockingbird Lane, FLeetwood 2-7541
Detroit, Mich., 13836 Puritan Avenue, VErmont 6-1909 • Indianapolis, Indiana, 2802 North Delaware St., WAlnut 3-1535
Milwaukee, Wis., 647 West Virginia Street, BRoadway 1-3234 • Newark, N. J., 1180 Raymond Blvd., MItchell 2-7586

4062

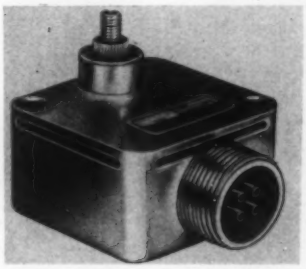
cent. Current drain is 100 ma. **Western Gear Corp.**, Electro Products Div., 132 W. Colorado St., Pasadena 1, Calif.

Circle 680 on page 19

Miniature Switch

has 360-deg rotary action

No. 9135 limit switch is hermetically sealed, has 360-deg rotary action with 180 deg pretravel and 180 deg overtravel. It is available with potted leads or pin connectors. Switch can be mounted flat with four fasteners or mounted vertically behind a retainer with washer and locknut. Extremely compact, it measures 2 x 1¾ x 1 in. Case is heavy nickel silver and withstands shock and severe environmental extremes. Units operate at 28 v dc or 110 v dc with 10 amp resistive rating, 4 amp inductive. Rated life is 100,000 cycles. **Haydon Switch Inc.**, Waterbury 20, Conn.



Circle 681 on page 19

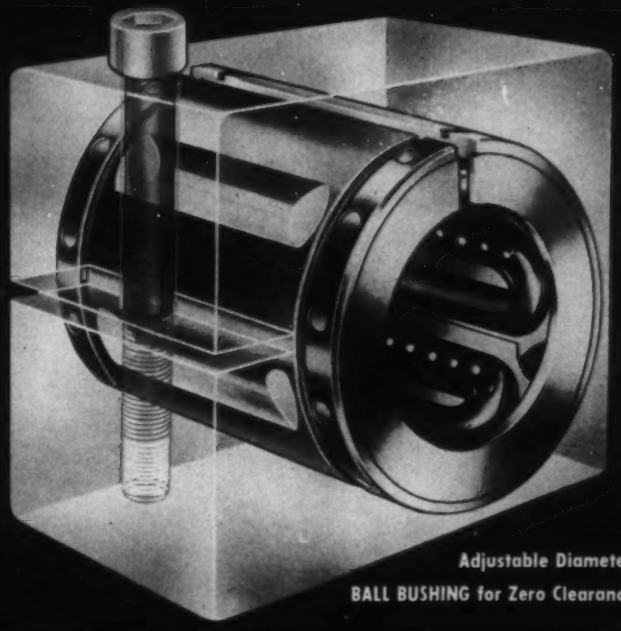
Slip Coupling

provides close torque regulation

L2 light-duty slip coupling for directly connecting two shaft ends has metallic friction plates and is available with bore dimensions of ½, ⅝ and ¾-in. diam in either member. Two types are available: Type 323 with disk-spring assem-

(*Continued on Page* 184)

NOW! *Adjustable Diameter and Open*
THOMSON
BALL BUSHINGS



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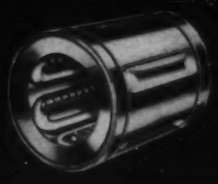
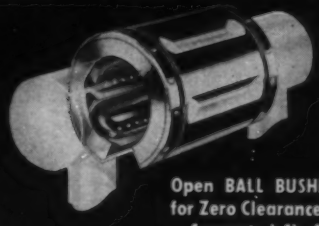
BALL BUSHING for Zero Clearance

The BALL Bearing for *all* your **LINEAR MOTIONS**



Precision Series "A" and Low Cost Series "B" BALL BUSHING.



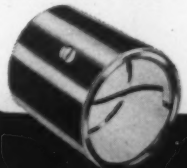
Open BALL BUSHING for Zero Clearance on Supported Shafts

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

Improve your product! Up-date your design and performance with Thomson BALL BUSHINGS!

LOW FRICTION · ZERO SHAKE OR PLAY
ELIMINATE BINDING AND CHATTER
SOLVE SLIDING LUBRICATION PROBLEMS
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



THOMSON INDUSTRIES, Inc.
Dept. E, MANHASSET, NEW YORK

Also manufacturers of NYLINED Bearings
. . . Sleeve Bearings of DuPont NYLON

Circle 512 on page 19

Designed for Strength and Safety

STRENGTH AND SAFETY are built-in features of this seat-belt buckle made from Republic Stainless Steel, Type 201. Fabricating operations include: shearing into blanks of .125 thickness, punching, a severe bend of 175° to form the hook.

SAFETY ASSURED by designing the high strength advantage of stainless steel into the simple beak-type buckle. No intricate springs or mechanisms to fail at the wrong moment. Both belt and buckle are rated 1000 pounds in excess of CAA specifications.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

with STAINLESS STEEL

SEAT-BELT MANUFACTURER LICKS CRITICAL PROBLEM WITH REPUBLIC ENDURO, TYPE 201

Here are the facts on a new and cost-cutting use of Republic ENDURO® Stainless Steel, Type 201, by Bunke-Musser Company, Jackson Center, Ohio, manufacturers of safety seat-belts for the automotive industry.

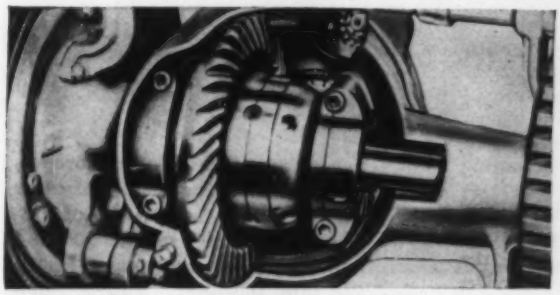
The most critical part of the entire assembly is the buckle. It must conform to Associated Seat Belt Manufacturers' specifications. These require that the buckles be subjected to a test pull of 1500 lbs., then reduced to 125 lbs. At this point, the pelican hook of the buckle must be capable of release at 45 lbs. pressure.

Prior to adoption of Type 201, another grade of stainless had been used. However, the slightly softer surface of this type resulted in a galling action at the fulcrum of the buckle when the release pressure was applied.

Bunke-Musser also experimented with carbon steel. But this required use of heavier gage, chrome plating and polishing, with the end result being much more expensive than stainless steel.

Now the company has standardized on Republic, Type 201, with excellent results. The buckles meet and exceed test specifications. The galling action has been eliminated. Tensile strength increased 200 lbs.

Types 201 and 202 are relatively new members of Republic's family of stainless steels. Republic Specialists will be happy to work with you in designing these new grades into your product. The 200 Series offers high strength, corrosion-resistance and easy forming on your present equipment. And they are readily available. Mail the coupon for more information, or if you would like a Republic Specialist to call at your plant. There's no obligation.



THERE'S NO SACRIFICE OF STRENGTH OR SAFETY in this drive axle designed from Republic Alloy Steel. In these fine steels you will find the highest strength values—plus an exceptionally high strength-to-weight ratio that permits transmission of hundreds of horsepower through tough, strong axles, shafts and gears, free from excess weight. Republic Alloy Steels are essential in designing smaller sections to carry heavier loads safely—essential in extending equipment life and reducing maintenance and replacement costs. Send coupon for data.

A BUILT-IN SAFETY FACTOR is one reason why Republic Nylok Nuts are being used in thousands of critical applications to resist shock, vibration and cyclic loading. The answer is in the nylon plug in one face of the nut which forces threads on other side tight against bolt or stud. Above, Nylok Nuts provide a powerful clamp action and keep vital steering tie-rod assembly securely in adjustment. Nylok Nuts can be removed for maintenance of parts, then re-used with no loss in holding power. And because either end is up they are ideal for automatic feeding and power wrenching. Send coupon for more facts.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-2865,
3130 East 45th Street • Cleveland 27, Ohio

☐ Please have a Republic Specialist call.
Send more information on:
☐ 200 Series Stainless Steel ☐ Alloy Steels ☐ Nylok Nuts

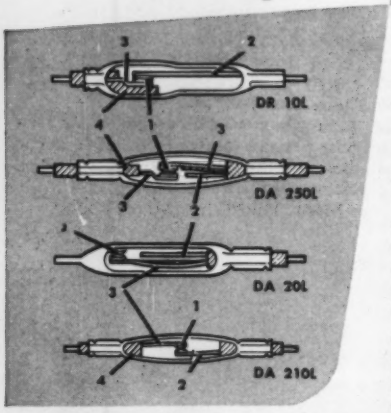
Name _____ Title _____

Company _____

Address _____

City _____ Zone ____ State _____

How CHACE Thermostatic Bimetal Actuates the FRANKLIN DALES Temp-Guard



The Temp-Guard is an extremely compact, self-contained and sealed tubular type circuit breaker manufactured by The Franklin Dales Co. Numerous variations of standard models are used in applications such as electric motors, operating on-off cycling systems, detecting fire and activating alarms, protecting electrical appliances, controlling regulating systems, automatically making or breaking current to solenoids, transformers, etc. The accuracy and dependability of this interesting device hinge upon its actuating element of Chace Thermostatic Bimetal.

The photo shows a typical Temp-Guard actual size. Others vary from 1 5/16" to 3 3/8" in length. The sectional drawings show four representative types of circuits; the DR models have the thermostatic bimetal element in contact with the case; the DA models have element insulated from the case. The numeral "2" indicates that case does not carry current. Parts numbered in the drawings are:

1. Contacts
2. Thermostatic Bimetal Element
3. Conductive Strip
4. Insulation

In all examples, the bimetal element deflects in response to changes in ambient temperature or heating of the element due to overload, making or breaking the circuit.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 514 on page 19

New Parts

(*Continued from Page* 181)

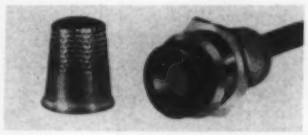
bly and adjustable torque range up to 9 lb-ft max; and Type 323A with coil springs to provide friction plate pressure. Size and number of coil springs can be varied, and coupling can be adjusted to suit any torque range from 0 to 7.3 lb-ft. Type 323 is for general application to provide overload protection between small motors and reducers, conveyors, feeding mechanisms, packaging equipment and similar machines. Type 323A is for installation where torque must be regulated closely and for applications involving 2 lb-ft or less torque. **Hilliard Corp.**, 100 W. Fourth St., Elmira, N. Y.

Circle 682 on page 19

Photoelectric Detector

subminiature unit is self-generating

Model 6350 subminiature photoelectric detector is self-generating, permitting simplification of circuitry. Rugged and highly sensi-



tive, it furnishes output proportional to input light intensity and loading. Typical input-output proportions are 300 mv at 100 ft-c into 1 megohm, or 20 μamp at 100 ft-c into 100 ohm. **Autron Engineering Inc.**, 1254 W. Sixth St., Los Angeles, Calif.

Circle 683 on page 19

Self-Contained Seal

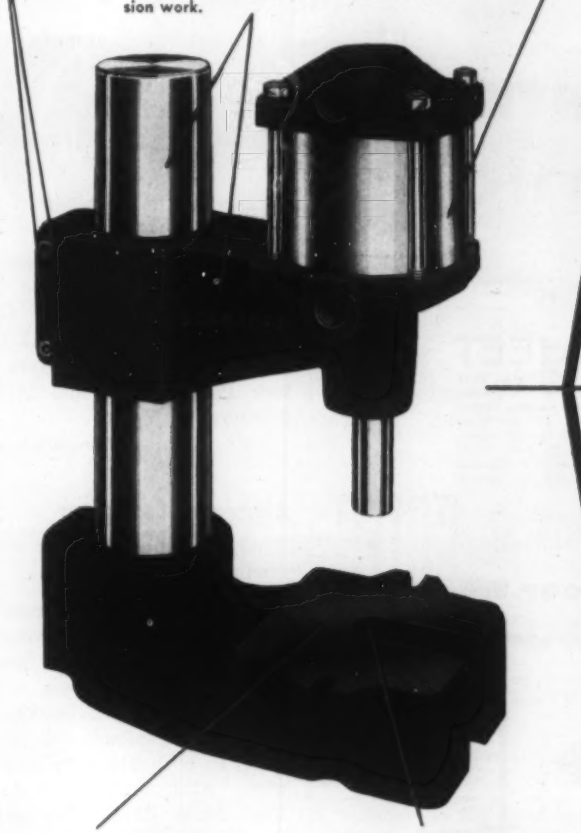
for use on any rotating shaft

BA12A-10 self-contained, compact seal is for use in all types of jet water pumps, oil pumps, reduction units or appliances. It can be used on any rotating shaft to seal liquids that will not attack Buna-N flexible parts or brass metal parts. Seal face, capable of withstanding high face loading and heat, is of filled true carbon to prevent porosity. Design also incorporates roll-type bellows, two-piece, rigid brass metal shell, and static O-ring

TWO-BOLT CLAMPING adjusts easily, positively from 0" to 7" in height, and swing arc 2" each side of center.

HEAVY-DUTY CYLINDER with extra heavy wall, tie rods and piston construction for longer life.

RIGID STEEL COLUMN and rugged cylinder bracket are accurately machined for precision work.



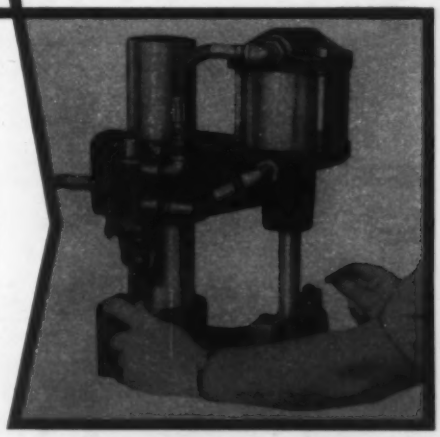
HEAVY, RUGGED BASE forms sturdy foundation for large machined-surface table area.

SPECIAL RECESS IN TABLE provides for punch-through operations.

NEW SCHRADER AIR PRESS

It's compact and power packed!

It stamps, coins, broaches, rivets, stakes, presses, shapes, bends, assembles—*many other uses!*



Modern "muscles" of compressed air never tire . . . get more work done at less cost!

This modern Air Press has unlimited possibilities for speed, power, positive performance. Available as single acting for impact jobs; double acting for squeeze and power withdrawals. It requires minimum space, next to no maintenance, is extremely versatile in adapting to operating controls. Can't be beat for low cost practicality.

Important feature: Control and speed of the extra heavy cylinder and ram can be varied as necessary, by using standard Schrader Air Control Accessories that adjust in seconds.

Write for Catalog data describing Air Press fully—including variety of controls, accessories and prices. You'll be surprised at the low prices!

A. SCHRADER'S SON
Division of Scovill Manufacturing Company, Incorporated
476 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
ESTABLISHED IN 1844

LEADERS IN AIR CONTROL SINCE 1844

Circle 515 on page 19

See us at Booth 421
Design Engineering Show
May 20-23rd, N. Y.

if you use small gears & pinions

IT WILL PAY YOU TO CHECK

GRC'S STOCK SHEET

Before you order gears or pinions, see GRC's new Stock Sheet. All items listed are cast from stock dies, individually or in various combinations of gears, pinions, hubs, shafts, etc. Holes, shafts, spacers, shoulders, etc., are made to your exact specifications at no extra tool charge, quantity permitting. Maximum O.D. about 1½", with 1/16" face width; wider faces for smaller diameters. • Unusual shapes, extra precise requirements, available on special order.

Write today for new stock sheet. SEND SPECIFICATIONS FOR PROMPT QUOTATION—100,000 TO MILLIONS.

GRIES

GRIES REPRODUCER CORP.

World's Foremost Producer of Small Diecastings
32 Second St., New Rochelle, N. Y. • Phone NEw Rochelle 3-8600

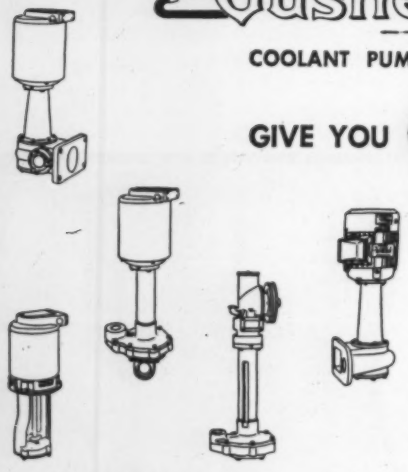
Circle 517 on page 19

Ruthman

Gusher

COOLANT PUMPS

GIVE YOU LONGER LIFE



The sturdy, simple construction of Gusher Coolant Pumps with fewer parts, assures you of long trouble-free life. Heavy Duty pre-lubricated ball-bearings require no further attention. There is no priming necessary. You get coolant flow from the moment you turn on the machine. So for trouble-free coolant systems always specify Gusher Coolant Pumps.

THERE'S A GUSHER FOR EVERY REQUIREMENT

Write Today for Catalog

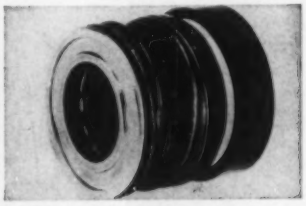
Ruthman MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road Cincinnati, Ohio

New Parts

which seals higher pressure, gives tighter fit and permits mounting the seal on a shaft from either direction. Seal is recommended



for operation against pressures to 100 psi, and is available for ⅝ and ¾-in. diam shafts. General operating limitation is 212 F with shaft speeds up to 1000 fpm. **Garlock Packing Co.**, 400 Main St., Palmyra, N. Y.

Circle 684 on page 19

Aluminum Conductor

polyethylene-covered wire by new process

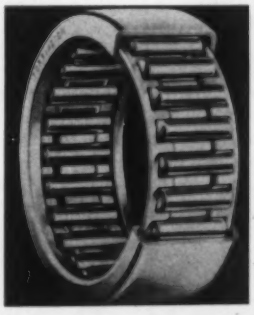
Aluminum conductor is now available covered with a relatively thin layer of protective and insulating polyethylene. Thickness varies with customer specifications. Conductor is available in coils or reels, in both line wire and phase wire. **Aluminum Co. of America**, 1501 Alcoa Bldg., Pittsburgh 19, Pa.

Circle 685 on page 19

Roller Bearings

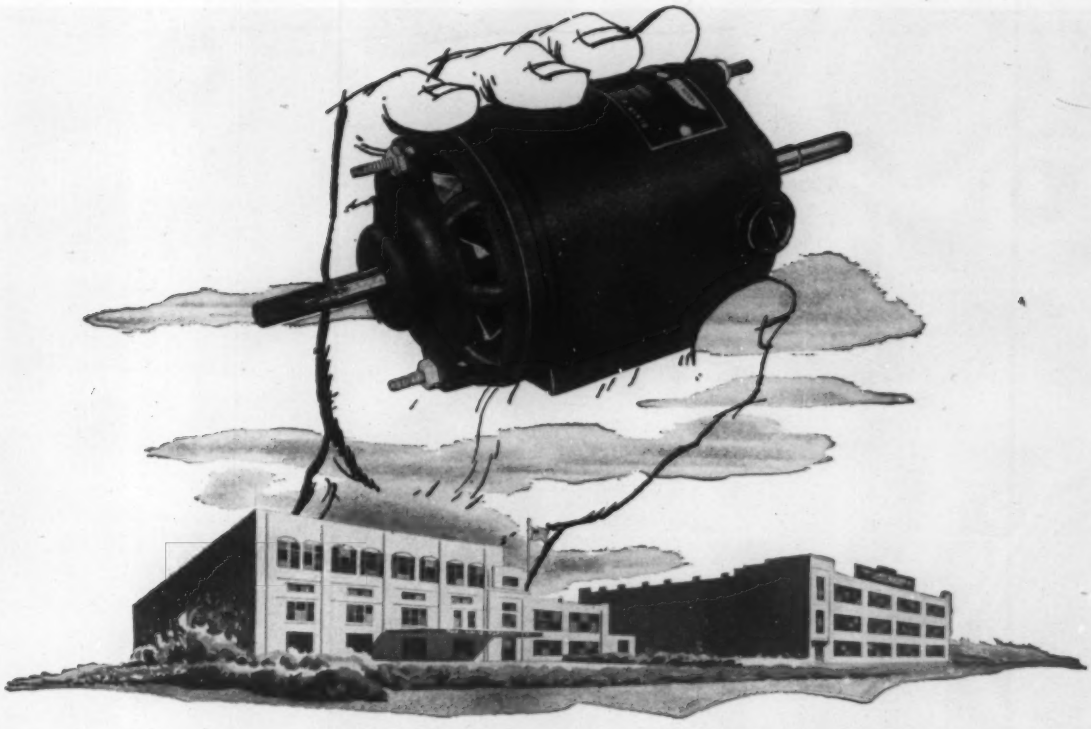
afford high capacity in minimum space

Drawn cup nonseparable roller bearings are designed for applications requiring precision, minimum



cross section, high-speed endurance or long pregreased life, such as in the textile, automotive, aircraft,

Circle 516 on page 19



CUSTOM-BUILT USE-ABILITY...

for your motor-driven products

Exceptional performance and dependability go with useability in Lamb Electric Motors because they are:

(1) "tailored" to the exact requirements of an application.

(2) built of quality materials by precision-minded personnel.

Our company is equipped and organized to *custom-manufacture on a volume basis;* hence high quality and controlled costs go hand-in-hand.

We would like to discuss these advantages with you for *your* new and redesigned products.

THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

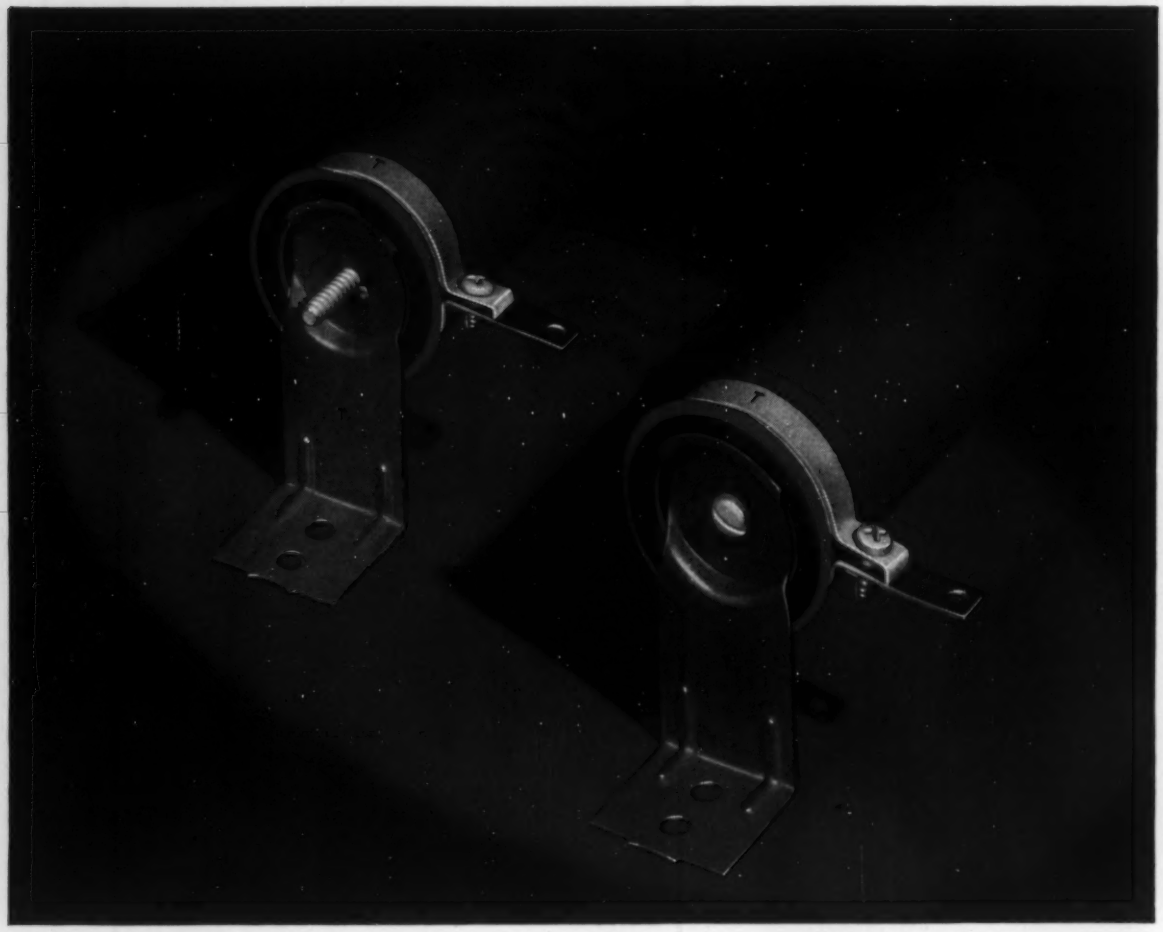
Swivel-mounted portable tool motor.

Aircraft de-icing pump motor.

Gear motor for slow-speed drive.

Turbine for canister-type vacuum cleaner.

If you are interested in any of the motors at left write and we shall be glad to send full information.



Engineered by Tinnerman...

4 SPEED NUTS® eliminate 8 parts in resistor assembly, cut costs 50%!

Tremendous assembly savings are often possible when Tinnerman SPEED NUTS are "designed into" new products. This is an example: Corning Glass Works, Corning, New York, adopted 4 special SPEED NUT brand fasteners and cut assembly costs on new power-type glass resistors by 50%!

Assembling power resistors is normally a slow and complex operation. Yet a pair of one-piece, spring-steel SPEED NUT angle brackets eliminated 4 of the 9 parts required by another fastening method and cut assembly time to a few seconds!

These corrosion-resistant, vibration-proof fasteners hold the resistor under live spring tension to avoid mechanical shock. Locating washers, lock washers and nuts are eliminated. Also, one-piece SPEED CLAMPS® that double as terminal bands eliminate 2 lock washers and 2 nuts.

SPEED NUTS permit maximum assembly savings on *new* products, but you can probably make worthwhile savings *right now* on current products.

Over 8000 types available. See your Tinnerman representative or write for Bulletin 333-1.

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BOX 6688 • DEPT. 12 • CLEVELAND 1, OHIO

TINNERMAN

Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hocano-Bundy GmbH, Heidelberg.

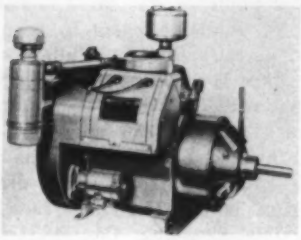
appliance and farm machinery fields. They can be mounted so that a hardened and ground shaft serves as inner race, facilitating use of larger and stiffer shafts. Inner races are available for use with soft shafts. Bearings are installed by a press fit without snap rings or shoulders. Design of the heat-treated steel retainer separates retaining and guiding functions, assuring positive roller retention. Turned-in lips of bearing cup exclude dirt and grit and retain lubricant. Bearings are available in 6 sizes with shaft diameters from 5/16 to 1⅛ in. **Torrington Co.**, Torrington, Conn.

Circle 686 on page 19

Air-Cooled Engine

is rated 56 hp at 2200 rpm

Model VR4D heavy-duty, air-cooled engine is rated 56 hp at 2200 rpm. Design incorporates Stellite exhaust valves and valve seat in-



serts, tapered, self-cleaning, main roller bearings on both ends of the crankshaft, rotary-type outside magneto, positive oil lubrication and efficient air cooling to 140 F. **Wisconsin Motor Corp.**, 1910 S. 53rd St., Milwaukee 46, Wis.

Circle 687 on page 19

Pressure-Vacuum Control

provides two switch actions

H27A pressure-vacuum control provides two completely separate switch actions, permitting control of two independent circuits and flexibility of switch arrangement. Unit has calibrated dial and single-turn adjustment knob and pointer for making pressure settings. Individual switch adjustments are made by independent hex-head screws inside the enclosure. Eight

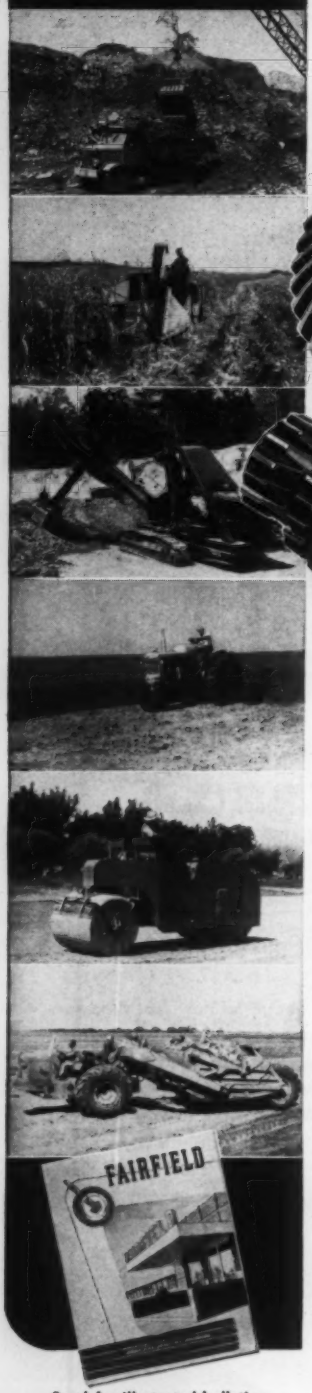
Everyone working on design and performance problems of fast mechanical motion should have a copy of "High Speed Motion Pictures at the Service of the Engineer," a new booklet obtainable without charge from . . .

It tells about the new fast films for high speed movies and how various industries are using the Kodak High Speed Camera.

We'll also send, at your request and while the supply lasts, a copy of a booklet, "Bibliography on High-Speed Photography."

Kodak

GEARS by FAIRFIELD



A Plus Value IN ANY PRODUCT!

If GEARS are a vital part of the product you make, there is no finer recommendation for the QUALITY of your product than to be able to say it is equipped with "FAIRFIELD GEARS."

Long producers of the gears needed in high grade trucks and tractors, Fairfield now brings the same standards for GEAR PERFORMANCE to a wide variety of products: Agricultural Implements . . . Power Shovels . . . Machine Tools . . . Diesel Locomotives . . . Road Graders . . . Lift Trucks . . . Road Rollers . . . Pump Drives . . . Winches . . . Military Vehicles . . . and a host of others.

Fairfield's facilities are unexcelled. Here "under one roof" in a new and ultra modern plant, Fairfield has everything needed for producing all kinds of gears: spur . . . herringbone . . . spiral bevel . . . ground tooth spiral bevel . . . straight bevel . . . coniflex bevel . . . hypoid . . . zerol . . . worms and worm gears . . . splined shafts . . . differentials. Get acquainted with Fairfield—your inquiry will receive prompt attention.

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MANUFACTURING CO.
2307 S. Concord Rd.,
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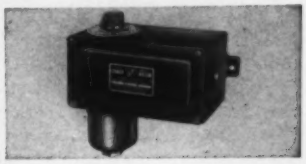
For FINE GEARS

Send for illustrated bulletin describing Fairfield's facilities.

New Parts

models are offered in a variety of adjustable ranges between 0 and 180 psi. Any of three standard types of switches is available: Nor-



mally open, normally closed, or double-throw with no neutral position. Switches are rated at 15 amp, 115 or 230 v ac and dc; 20 amp ac switches are also available. **United Electronic Controls Co.**, 79 School St., Watertown, Mass.

Circle 688 on page 19

Variable-Speed Pulleys

provide long service without adjustment

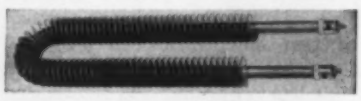
Variable-speed pulleys for 1 and 1½ hp 1750-rpm applications have speed ratio of 2½ to 1. There are no intricate parts to require periodic adjustment. Pulleys use standard B-section V-belts. Model 175 is rated at 2/3-hp at 1150 rpm and 1 hp at 1750 rpm. Model 180 is rated 1 hp at 1150 rpm and 1½ hp at 1750 rpm. Pitch diameter of both is 5.93 in. **Lovejoy Flexible Coupling Co.**, 4882 W. Lake Street, Chicago 44, Ill.

Circle 689 on page 19

Tubular Heaters

for forced or natural convection air heating

Finned tubular heaters are designed for forced or natural convection air heating in ducts and space heaters, baseboard room heaters, ovens, railroad cars and other applications. Fin is spirally-edge wound from a continu-



ous strip of steel, then siver brazed to surface of the heater sheath, forming a permenent bond which insures good heat transfer. Terminal construction includes standard

Self-aligning

FOR LONGER LIFE

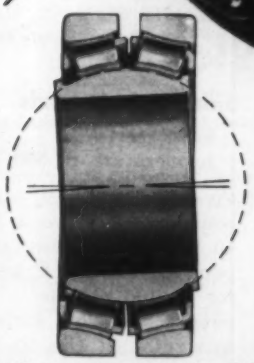
Not even misaligned shafts or supports impair the efficiency of this easy-to-mount LINK-BELT roller bearing

THE equipment manufacturer seeking lower manufacturing costs plus the ultimate in free-rolling efficiency need look no further than this Link-Belt roller bearing.

- **SELF-ALIGNMENT** compensates for inaccuracies in machining and assembly of equipment.
- **EASY MOUNTING.** Bearing is securely and quickly locked by a heavy collar to commercial shafting.
- **COMPACTNESS** offers design flexibility.

You'll find equally important economies throughout industry's most complete line of ball and roller bearing blocks. Ask any one of 40 Link-Belt offices for Book 2550 containing full information.

Series 400 roller bearings



FREE ROLLING—SELF ALIGNING. Spherical inner ring aligns freely in any direction. Load is distributed over entire roller, assuring full capacity. Destructive edge loading cannot occur.

LINK LB BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14 440-A

Breeching fabricated complete by Littleford Bros. Inc., for Ohio Edison Co., Akron

BIG SCALE fabricating at LITTLEFORD

Littleford fabricates all metals in almost any size. Why not use Littleford's 175,000 square feet of modern fabricating facilities, 300 skilled craftsmen and 75 years experience to assure quality fabricating for your individual needs? Send blueprints for prompt estimates. No obligation, naturally. Littleford Bros., Inc., dept. LB 260—424 E. Pearl St., Cincinnati 2, Ohio.

Circle 523 on page 19

Work where

Pump Engineering

reaches its peak!

It takes exceptional pumps to feed the most powerful propulsive system ever built—the Large Rocket Engine. And it creates an exceptional career for the man who develops these pumps.

Rocket Engineering offers the most interesting opportunities in the pump engineering field today. Your experience with commercial pumps and compressors will be extremely useful—to help solve problems of head capacity, power and speed never before encountered. You'll gain technical and professional experience that is unobtainable elsewhere... your contributions to the advanced techniques of pump design will be recognized and rewarded.

Rocketdyne builds high thrust, rocket propulsion systems for America's major missiles. You'll work with the leading producer in the nation's fastest growing industry.

If you are an experienced pump engineer with the ambition to break new ground, tell us about yourself. Chances are, your creative ability can open up a new career for you in Rocket Engineering—more fascinating and more valuable to you than the work you are now doing. Write: Mr. A. W. Jamieson, Rocketdyne Engineering Personnel Dept. MD-4, 6633 Canoga Avenue, Canoga Park, California.

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.

BUILDERS OF POWER FOR OUTER SPACE

New Parts

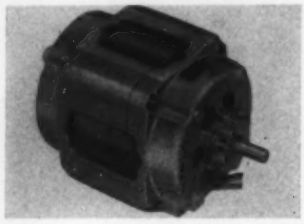
screw and nut type, moisture-resistant silicone seals on low-temperature units, and hermetically sealed terminals with ceramic-to-metal seals for temperatures above 450 F at terminal ends. Standard 2 and 3 kw heaters are available in 115 or 230 v. Wattage ratings are from 2000 to 8000. **Vulcan Electric Co.**, 85 Holten St., Danvers, Mass.

Circle 690 on page 19

Induction Motor

with various windings for 1/300 to 1/75 hp loads

Miniaturized model 9200 motor is for use with tape recorders, office machines, aircraft instruments and similar applications. Model



is available in permanent split capacitator, single phase, 50/60-cycle induction, torque, and synchronous types, and in two or three-phase models. Horsepower range is 1/300 to 1/75. **Howard Industries, Inc.**, 1760 State St., Racine, Wisc.

Circle 691 on page 19

Silicone Compounds

have service temperature to 500 F

Five heat-resistant silicone compounds with Shore A hardness of 40 through 80 have service temperatures to 500 F and to 600 F for limited periods. Three compounds with low shrinkage characteristics in the 50 through 70 durometer range permit molding of parts and holding of close tolerances in existing tools originally designed for organic rubbers. Dow-Corning silicone resin DC-301 compound for molding of parts requiring exceptional electrical and physical properties at high temperatures is also available. **Acushnet Process Co.**, New Bedford, Mass.

Circle 692 on page 19

Designing the wheels of their unique "Kompactor" with Lukens heads enabled The Buffalo-Springfield Roller Co., Springfield, Ohio, to simplify construction, save costs, and give new efficiency to huge self-propelled road rollers. Is there an idea here for you?

Imagination pays off... when you design with Lukens Heads

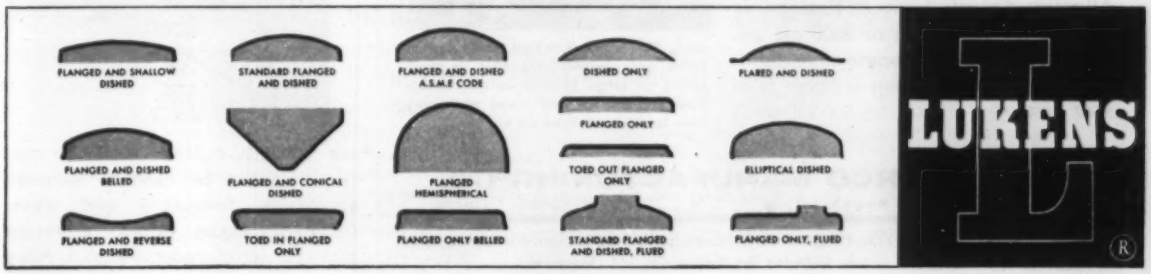
■ Take eight Lukens heads, weld them together in pairs, and what have you got?

Four brute-strength wheels with built-in ballast tanks, for one thing. Lowered costs, for another.

Buffalo-Springfield added steel pads to the wheels of their giant earth "Kompactor," achieving such operating efficiency that this one machine is able, when called upon, to combine the functions of two other machines.

Whether you build wheels, valves, chemical equipment, heavy or light machinery, imaginative use of Lukens heads may reduce design complexity, eliminate costly fabrication steps, and raise efficiency. Lukens' fifty-year experience as the leading producer of spun and pressed steel heads for many applications is at your service. Write for catalog 934, "*Pricing and Engineering Data*," Lukens Steel Company, Coatesville, Pa.

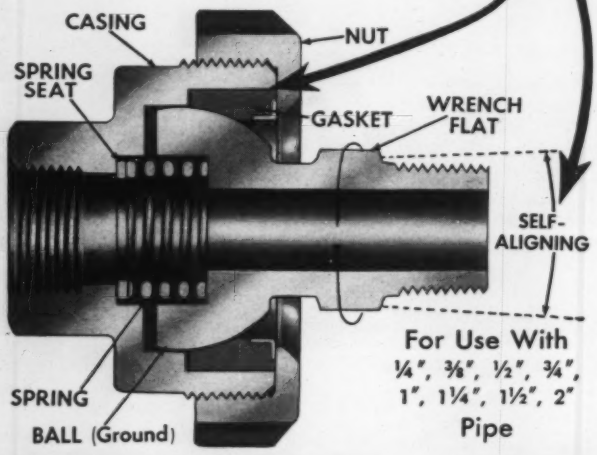
Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels



Circle 524 on page 19

TWO BIG ADVANTAGES!

1. Self-Aligning Ball
2. Chemically Inert Seal



BARCO SWIVEL JOINTS

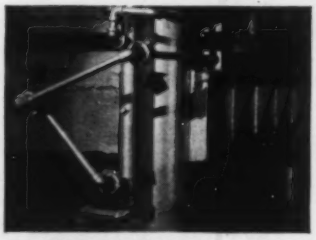
for STEAM, OIL or WATER LINES

Two important features give Barco Swivel Joints capabilities not found in ordinary swivel joints:

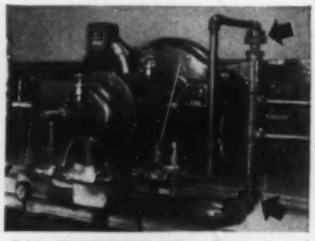
SELF-ALIGNING—Provides a wide tolerance for pipe fitting and machine alignment. Saves endless hours installation time and permanently protects against binding and wear.

CHEMICALLY INERT SEAL—Pressure sealing and automatically self-adjusting for wear. Ideal for steam service. Uniform performance over temperature range from −50° to +600°F. No lubrication needed.

Send for Catalog 265B, "Barco Self-Aligning Swivel Joints." Ratings as high as 750 psi steam or 3000 psi hydraulic. Sizes ¼" to 2"; angle or straight. *Ask for recommendations—Barco is at your service.*



PLATEN PRESS—Barco Swivel Joints (see arrows) in "dog leg" piping provide flexible connection to moving platen of press. Platen moves up and down. Line handles steam and cold water alternately.



OIL BURNER—Two Barco Swivel Joints (see arrows) mounted as pivot points on hinge provide swivel connections for fuel oil and steam atomizing lines to door mounted oil burner.

FOUNDED 1908 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.
506E Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

ENGINEERING DEPARTMENT
EQUIPMENT

Lettering Template

contains new symbols

No. 35 lettering template has latest symbols for draftsmen and engineers and conforms to recent changes in military and industrial standards. It contains full capital alphabet and numerals, with extra

symbols for zone blocks, delta and surface-rougness symbols, cutting-plane arrowhead, and circles with marked quadrants for ⅜, ½ and ⅝-in. diameter. Corners are rounded to give ¼, ½, ¾ and 1-in. radius arcs of 90 deg. Template is of 0.065-in. thick aquamarine plastic. Drawing edges are tapered, and finger relief at edges permits easy lifting. **E. F. Twomey Co. Inc.**, 728 W. 10th Place, Los Angeles, Calif.

Circle 693 on page 19

Vibration Measuring Unit

measures vibration and displacement

Optron is an optical device for measuring displacement and vibration of any body, regardless of size, shape or composition. Operat-

ing without contact with the material, it can be used to measure amplitude, frequency and waveform of shake tables, vibration pickups, accelerometers and relay

where DEPENDABILITY counts most—

CONVAIR F-102A INTERCEPTOR

depends upon . . . .

VICKERS®

SMALL, LIGHT WEIGHT,
EFFICIENT HYDRAULIC EQUIPMENT

Vickers Flow Sensitive Pressure Regulator permits ram air turbine to generate needed hydraulic flow down to minimum airspeed by regulating the pressure to that which the turbine can produce.

Vickers Thermal Operated Relief Valves protect the primary and secondary hydraulic systems from overheating by automatically depressurizing the circuit at a preset temperature.

Vickers 3000 psi Variable Displacement Piston Type Pumps supply power to the primary and secondary hydraulic systems on the Convair F-102A Interceptor.

Vickers 3000 psi Constant Displacement Piston Type Pump operated by ram air turbine supplies both emergency hydraulic and electric power through the constant speed motor driven alternator in event of engine failure.

Vickers Constant Speed Hydraulic Motor drives the emergency alternator from either the ram air turbine or the secondary hydraulic system.

The Convair F-102A all-weather supersonic stratospheric interceptor depends on Vickers Hydraulics for the following important functions:

- Primary and secondary hydraulic systems
- Ram turbine operated emergency hydraulic system
- Emergency electrical system

The components shown here were selected by Convair for their outstanding dependability and the additional advantages they offer in superior performance. Their technological advancement keeps pace with aircraft development. The pumps are characterized by minimum heat rejection and highest overall efficiency . . . all units shown have small size and light weight. For further information, ask nearest office listed below for Bulletins A-5200-D and A-5209.

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DIVISION OF SPERRY RAND CORPORATION

Aero Hydraulics Division—Engineering, Sales and Service Offices:

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OVERSEAS REPRESENTATIVE: The Sperry Gyroscope Co., Ltd.—Great West Road, Brentford, Middx., England

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

VS-100

new all-electric machine tool feed drive

No pick-off gears or gear changes are necessary with the VS-100. Infinitely variable 100 to 1 speed range offers high speeds for rapid traverse as well as the slowest feed rates.

Feeds may be precisely selected and rapidly changed, even during a cut. The push button operator's station provides easy, instantaneous feed control. This remote station contains controls for start, stop, jog, reverse, and speed changing . . . ideal in pendent station mounting for maximum operator's convenience. Additional functions, such as automatic dwell and automatic feed programming are available for the operator's station.

The VS-100 operates from 220 or 440 volt, single phase, a-c. circuits. Seven sizes are available ranging from ½ thru 4 horsepower. For complete details write for bulletin D-2501. D-1540

RELIANCE R ELECTRIC

AND ENGINEERING COMPANY

DEPT. 284A, CLEVELAND 17, OHIO • CANADIAN DIVISION: WELLAND, ONTARIO

Sales Offices and Distributors in Principal Cities

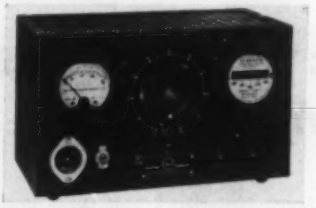
contacts. Spot of light with effective diameter of 0.0001-in. from a cathode ray tube is projected by an optical system onto the work. Multiplier photocell moves the spot to follow the motion. Accuracies of measurement are in microinches. Full scale range can be as high as 10 in. with different optical systems. **Optron Corp.**, 3526 State St., Santa Barbara, Calif.

Circle 694 on page 19

Voltage Control

for testing 400-cycle aircraft components

Compact voltage control unit operates on 115-v 400-cycle single-phase ac and provides continuously adjustable output from 0 to 115 v



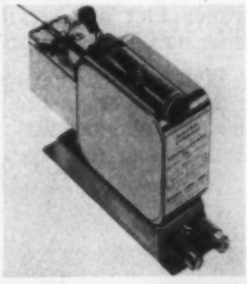
under maximum load of 15 amp. Instrumentation includes 3½-in., 21-reed, ½-percent accuracy frequency meter and 2 percent accuracy ac voltmeter. Weight is 12 lb. **Opad Electric Supply**, 69 Murray St., New York 7, N. Y.

Circle 695 on page 19

Oscillograph

for multichannel recording systems

Model M-133 pen motor is a compact, lightweight unit for multichannel recording systems. Pen



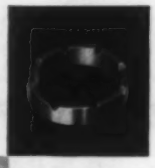
motor includes an integral mounting base which permits 1¼-in. on-center spacing of units. Built-in micrometer setscrew provides ac-

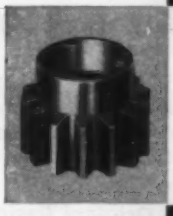
a new expanded field of

BEARING DESIGN and APPLICATION

The inauguration of Bunting's new facility for engineering and manufacturing bearings and parts of Sintered Powdered Metals opens a wide new area of opportunity to all mechanical industry.

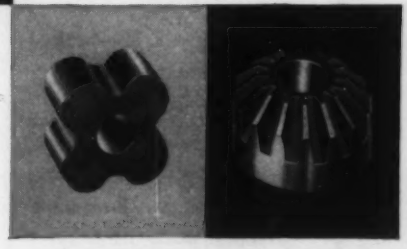
Sintered Powdered Metal Bearings and parts offer real economies in design. Bunting Engineering and manufacturing skill and traditional technical responsibility assure your most advantageous use of this material.





A competent group of Bunting Sales Engineers in the field and a soundly established Product Engineering Department put at your command, comprehensive data and facts based on wide experience in the designing and use of both Cast Bronze and Sintered Powdered Metal Bearings and parts.

● *Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.*



Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

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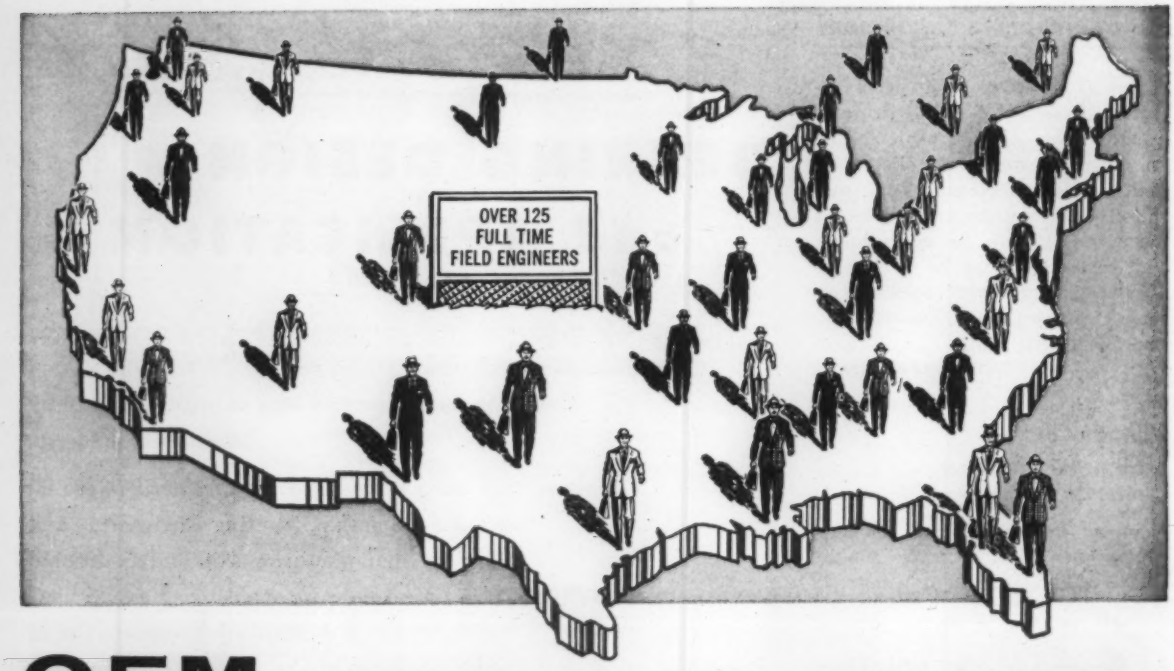
Circle 528 on page 19



OEM USERS OF AIR CYLINDERS

have available Bellows Nation-Wide Field Service

Original equipment manufacturers incorporating fluid power circuits in their products to meet the growing demand for higher output and lower cost face two problems:

Original Design . . . and Field Service

Bellows Air Motors and other Bellows "work devices" lend themselves readily to OEM design. For example, all operating valves, actuating elements, speed control regulators are built into the units, simplifying circuit and installation problems. All units are compact, streamlined, fit well into crowded quarters. All units can be positively interlocked with reciprocating machine elements.

More than 125 Bellows Field Engineers devoting their full time to the sales and service of Bellows equipment. One or more Field Engineers in every major industrial area in the United States and Canada . . . and in Australia, Europe and the British Isles provide certain assurance that any service requirement on any Bellows unit will be handled promptly.

And of equal importance — every Bellows Field Engineer is fully capable of working with you and your engineers in developing the most effective and most economical way of incorporating "fluid power" control and operation into your product.

We have prepared a new booklet showing a little of the widespread usage of Bellows Air Motors and related "fluid-power" devices in many OEM products. It makes interesting reading for the manufacturer looking for ways to increase the productive efficiency of his product. It is free on request. Write Dept. MD457, The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario.

1425A

The Bellows Co.
AKRON 9, OHIO

Circle 529 on page 19

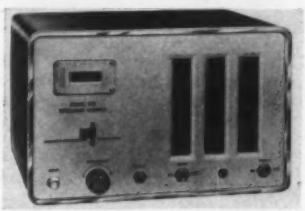
curate pen alignment to a common time axis; second setscrew is provided for pen zero adjustment. Unit is direct inking, with disposable ink cartridge hermetically sealed to prevent evaporation and maintain correct ink viscosity. Frequency response with constant-current input is flat from dc to 60 cps, with fall-off of 12 db per octave from 60 to 200 cps. Sensitivity is 20 ma rms full scale. Unit is 4¾ in. long, 1¼ in. wide, 3⅞ in. high and weighs 1½ lb. **Massa Laboratories Inc.**, 5 Fottler Rd., Hingham, Mass.

Circle 696 on page 19

Totalizing Counters

in models with 1 to 4 decades

Direct-reading high-speed Model 300 electronic totalizing counter offers absolute accuracy, two outputs (relay and pulse), reliability,



rugged construction and small size. Models have from 1 to 4 decades; count capacities range from 999,-999 to 999,999,999. Counts per second are 0-150 to 0-100,000. **Computer - Measurements Corp.**, 5528 Vineland Ave. N., North Hollywood, Calif.

Circle 697 on page 19

Missing Pulse Detector

checks performance of pulse-modulated tubes

Tube-testing instrument checks performance of pulse-modulated

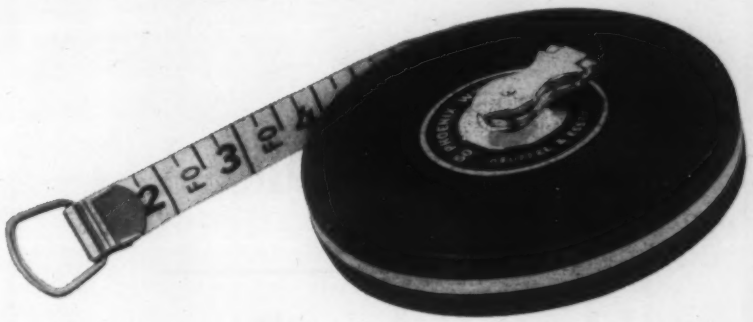
magnetrons, klystrons and similar tubes. Unit incorporates two in-

ALBADURE*... the steel tape with lasting legibility

Here is a steel tape that stays clear and legible long after markings on other tapes have worn off.

An amazingly tough plastic coating on both sides of the line protects the white background, the graduations and numbers on ALBADURE tapes, giving their surfaces tremendous resistance to abrasion and corrosion. To quote a State surveying party report, "If ALBADURE stood up in this tough mud and sand, it'll stand up anywhere." Available in all standard lengths, widths and graduations, in cases and on reels.

PHOENIX WYTEFACE®... the woven tape that outlasts others 3-1



PHOENIX WYTEFACE (non-metallic) Woven Tapes made from extra strong synthetic yarns, are harder wearing, with higher tensile strength and dimensional stability than ordinary woven tapes. A special plastic coating on both sides protects the line against hard use, water, stones or brush.

The end of the line is enormously strengthened by a lamination of Flexi-Foam, a spongy plastic-rubber. No stitches or hinge point to weaken the line.

A Highway Engineer reported of the non-metallic PHOENIX WYTEFACE, "It has at least three times the life of an ordinary metallic tape." *Ask Your K & E Dealer!*

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Circle 530 on page 19

MECHANICAL ENGINEERS

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A SUBSIDIARY OF HOFFMAN ELECTRONICS CORP.
3761 South Hill St., Los Angeles 7, Calif.
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Circle 531 on page 19

Design Guide to

"Adjustable-Speed Drives"

- ELECTRICAL
- MECHANICAL
- HYDRAULIC

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

Engineering Equipment

put connectors, one for negative-detected RF pulse, other for negative reference trigger. For missing pulse, output is positive 15-v pulse that registers on counter. Normal tube operation produces no output pulse. **Manson Laboratories,** Dept. O, 207 Greenwich Ave., Stamford, Conn.

Circle 698 on page 19

Calculator

circular slide rule has 3 in. diameter

Small calculator, designated Controller, performs all calculations except addition and subtraction. Constructed of aluminum, it is only

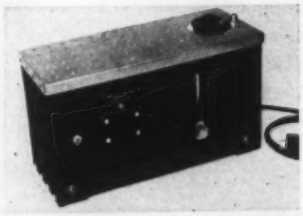
3 in. in diameter and weighs 1 oz, including vinyl case. Unit is unbreakable, rustproof, and is unaffected by climatic conditions. **Silver Bells Ltd.,** Controller-Calculators Div., 600 Sixteenth St., Oakland, Calif.

Circle 699 on page 19

Vibration Tester

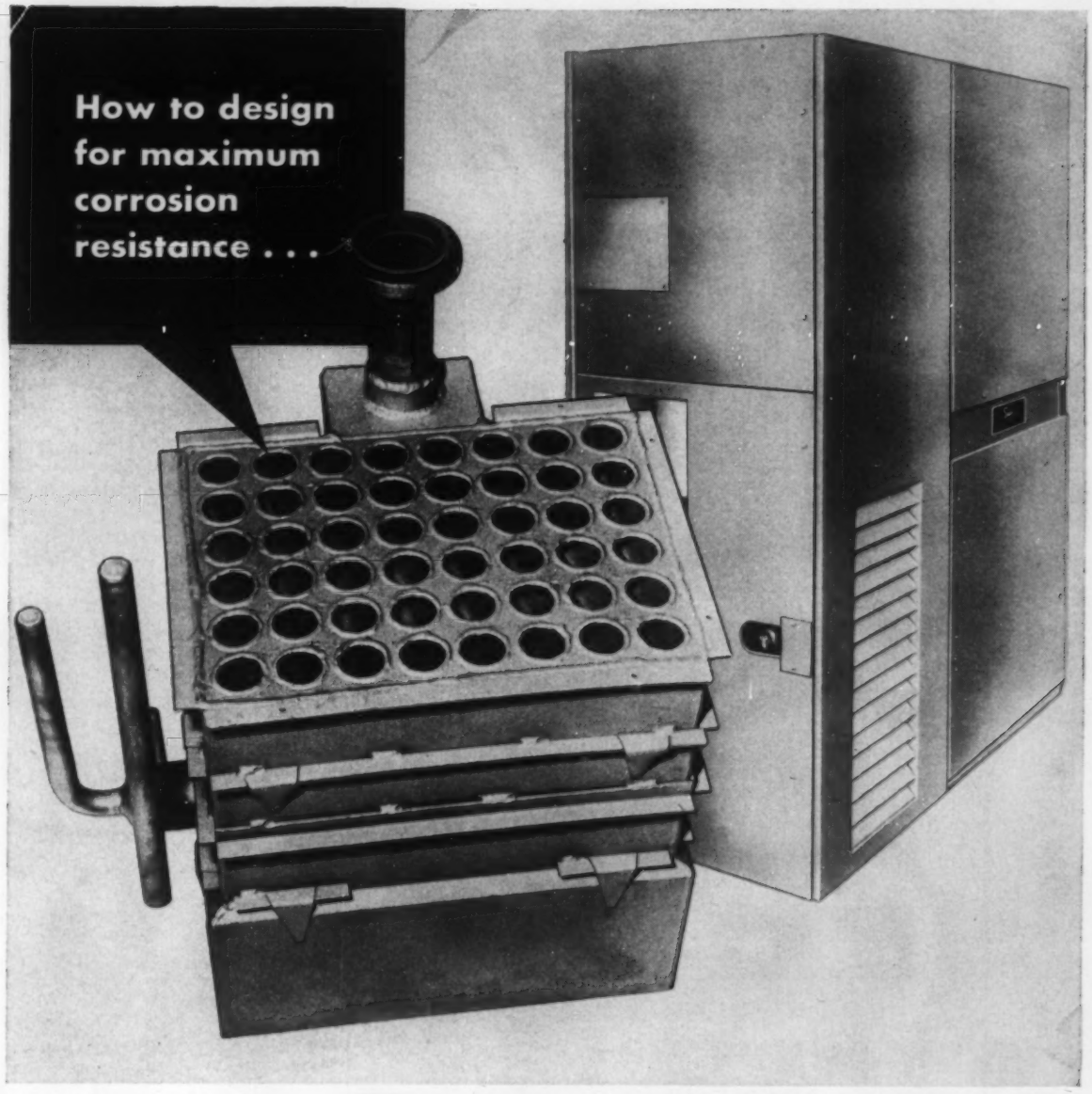
economical unit for small parts

Vibration testing of small items up to 5 lb is provided by Model 14-28, which meets frequency and amplitude specifications of MIL-



STD-202. Frequency adjustment is infinitely variable from 10 to 55 cps while machine is running. Amplitude setting is 0 to 0.040-in. **Ahrendt Instrument Co.,** 4910 Calvert Rd., College Park, Md.

Circle 700 on page 19



. . . insist on *Carpenter* Stainless Tubing

Severe corrosion problems were encountered in handling hot flue gas and boiling lithium bromide solution in this generator for a gas-fired year-round air conditioner. The tubes transfer heat from the flue gas to boil a solution of 50% lithium bromide and water surrounding the tubes.

A change to Carpenter Stainless Tubing ended the corrosion problem. Handling this unusual combination of corrodents is just one more example of how Carpenter quality pays off in improved products and lower costs. There's a Carpenter Distributor as near as your telephone. Call him today.

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Stainless Tubing & Pipe

Circle 532 on page 19

MECHANICAL ENGINEERS

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PRODUCTS FOR PROGRESS BY THE MEN OF AERONAUTICAL

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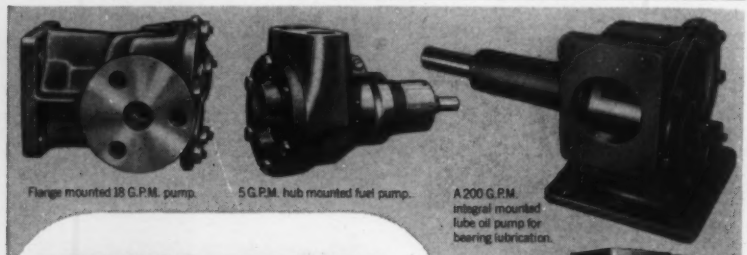
Flange mounted 18 G.P.M. pump.
5 G.P.M. hub mounted fuel pump.
A 200 G.P.M. integral mounted lube oil pump for bearing lubrication.
A 90 G.P.M. flange mounted pump with valve on head.
A 10 G.P.M. opposite port oil pump built to specifications.

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Shown here are only a few of many special pumps, ranging in size from 5, 10, 18, 90 to 200 gallon per minute. Smaller and larger pumps also available. Send today for folder 57Sh.

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See our catalog in Sweets

Circle 534 on page 19

THE ENGINEER'S Library

Recent Books

Gear Design and Production: Rules and Working Formulas. *By Reginald Trautschold; 204 pages, 6 by 9 in., clothbound; published by and available from Columbia Graphs, Columbia, Conn., $4.50 per copy.*

Recent advances in production of quality gearing are described by this book. Its main purpose is to restate the principles of gearing, prove the rules, and provide convenient formulas for the many critical computations entailed in gear design. The various standard varieties of classes of gear units, as well as specific applications, are discussed. Production methods, materials and heat treatment, inspection and calibration of gear teeth, are covered.

Manufacturing Methods and Processes. *By Arthur C. Ansley; 561 pages, 6 by 9 in., clothbound; published by Chilton Co., Chestnut and 56th Sts., Philadelphia 39, Pa.; available from* MACHINE DESIGN, *$12.50 postpaid.*

Designed to give a broad, general background on the latest developments in manufacturing methods and processes, this book describes briefly the methods and equipment used in each process. The book places its principal emphasis on the type of parts made by each process, chief applications, and cost. Coverage ranges from familiar processes such as sand casting, to powder metallurgy, investment casting, plastics processes, ultrasonic machining, dielectric heating, electronic printed circuits and automation. The chapter on assembly processes emphasizes the savings that can be made in this phase of manufacturing.

Ideas on Specifications. *By Herbert Whittemore, formerly chief of engineering, Mechanics Section, National Bureau of Standards; 128 pages, 6 by 9 in., clothbound; published by and*

TOUGH THERMOSTATS SAY "RELAYS FOR SISSIES"

Snap-Action Thermoswitch Units Boss Big Loads Without 'Em

"Relays? Who needs 'em?"

ASHLAND, MASS. — If you want to control good-size electrical loads with a precision thermostat, and you don't want to bother with relays, Fenwal has just the thing.

Fenwal has two series of snap-action Thermoswitch® units, more than twelve models, all based on the same idea — and they don't need relays.

The idea is this:

A liquid responds to temperature changes by expanding or contracting, and moves a bellows assembly. The bellows assembly works a snap-switch with a push-rod, making or breaking a circuit.

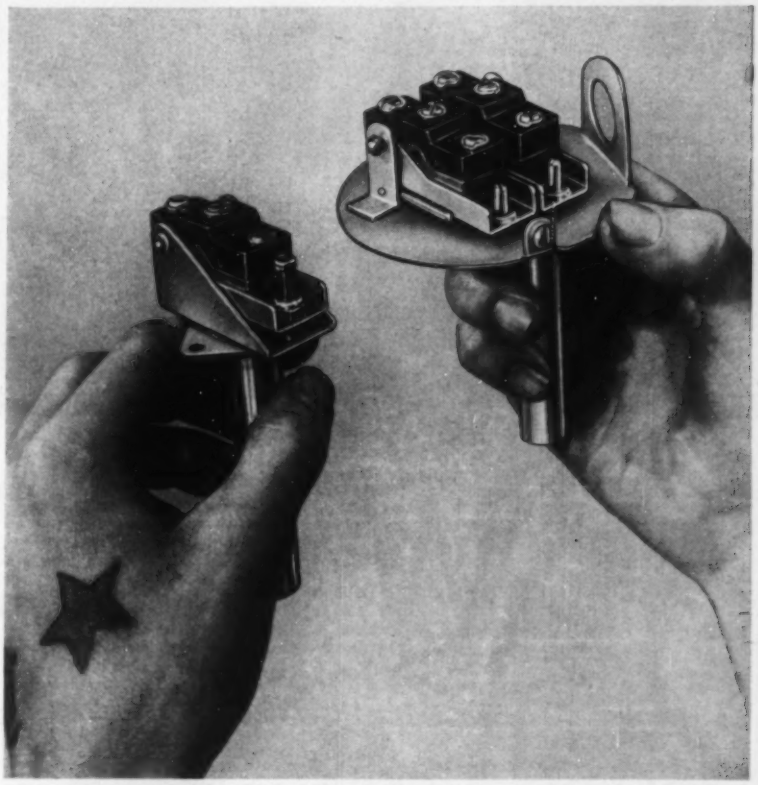
This arrangement will let you control electrical loads up to 20 amps, 115-250 volts A.C., or 10 amps, 125 volts, D.C., without relays, and with a high degree of accuracy.

Fenwal's two series of these remarkable units are called the 20000 and the 22000. The first has only one snap-switch, and the second has two. Two snap-switches and one unit, of course, give you compact control for two-stage heating or cooling.

As for adjusting temperatures — your own men can do it simply in the field. An easy-to-get-at set screw on each switch does the trick. On the double switch models, each switch is set independently.

As for accuracy and speed of response — the units control to within ±2° F.

As for cost — Fenwal has designed both series of snap-action THERMOSWITCH controls along "building block" lines to save you money. That is, Fenwal can assemble specialized units for you from a selection of standardized temperature ranges, head types, "application-rated" snap-switches, and mounting styles.



THESE TWO FENWAL SNAP-ACTION THERMOSWITCH UNITS — control loads up to 20 amps, 115-250 volts A.C., or 10 amps, 125 volts D.C. — without relays. These are only two of the twelve models available from Fenwal's Series 20000 (one-switch) and Series 22000 (two-switch) snap-action units.

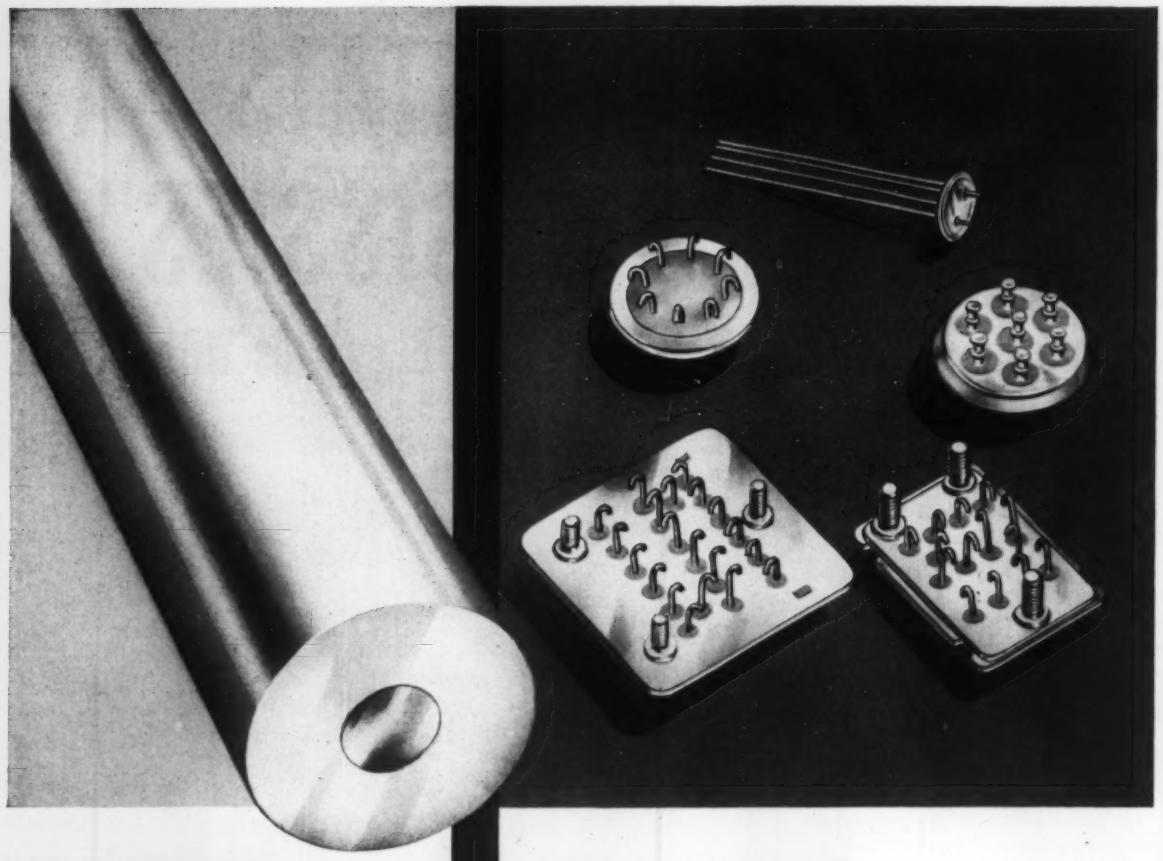
The temperature ranges you can choose extend from −75°F. to +300°F.

If you choose these controls for your application, you will not be choosing an untried product. You will be joining a large group of satisfied users who have put them to work in such varied equipment as air conditioners, hot-drink vending machines, laundry equipment, and dishwashers.

Designers — write for details on the Fenwal Series 20000 and 22000 snap-action THERMOSWITCH units. You will want those details at your fingertips. Write to **Fenwal Incorporated, 194 Pleasant Street, Ashland, Massachusetts.**

Fenwal

CONTROLS TEMPERATURE ...PRECISELY



NEW

General Plate COPPER CORED Glass Sealing Alloy Wire

Increases Electrical Conductivity — Saves Time — Cuts Cost

Here's a case where two metals are much better than one. Built around a 30% copper clad core, General Plate Glass Sealing Alloy Wires have up to three times more electrical conductivity than solid lead wires of the same size.

This means you can substantially increase the current carrying capacity of your solid sealed leads without going to larger diameters — or, if you have a miniaturization problem, you can reduce sealing wire diameters correspondingly by using General Plate Cored Wire.

General Plate Copper Cored Glass Sealing Wires are being used more and more for better performing glass-to-metal seals in hermetically sealed devices such as switches, relays, coils, controls and vacuum tubes.

General Plate Copper Cored Glass Sealing Wires are now available in #52 alloy, Type 446 Stainless, low carbon steel and other glass sealing alloys. Write for Technical Data Bulletin 706.

For full details on the complete line of General Plate Clad Metals, write today for your free copy of our new PR-700A Catalog.

You can profit by using General Plate Clad Metals

METALS & CONTROLS CORPORATION

General Plate Division

2004 Forest Street
Attleboro, Massachusetts

Circle 536 on page 19

available from Columbia Graphs, Columbia, Conn., $3.00 per copy.

This book contains information on how effective specifications should be written to avoid controversies and to secure the item desired. It presents examples of problems which result from improperly stated specifications. Many of the cases selected to illustrate a principle are taken from the field of engineering materials or assemblies. The engineer and specification writer will find accurate and authoritative information which will help in drafting sound material or commodity specifications or standards.

Shaping America's Products. *By Don Wallace; 193 pages, 8 by 10½ in., clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$10.00 postpaid.*

This book shows how well-designed products evidence forethought and planning combined with pleasing appearance and good taste. Thirty-one case studies show the ways by which the industrial designer may improve both appearance and function of a product.

Government Publications

Water Bearings and Air Bearings with Pressure Lubrication, PB 121405. *By F. Gottwald, Darmstadt, Germany; 11 pages, 8½ by 11 in., paperbound; translated by F. Rizzo for Bureau of Ships, USN; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.; 50c per copy.*

Water or air fed into a bearing under pressure acts as a safe load-carrying film of lubricant which can be maintained even at rotational speeds so low that the conventional slide bearings cannot retain the hydrodynamic lubricating film. Construction, operation, and results of experiments with a conical bearing for either air or water lubrication are described.

Cast Copper Anti-Friction Steel, PB 121364. *By A. A. Lunev; 15 pages, 8½ by 11 in., paperbound;*

(*Continued on Page 208*)

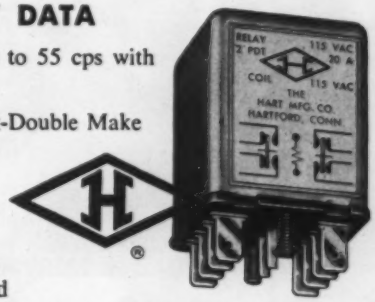
'Diamond H' Power Relays High Capacity A.C. or D.C. Midgets

Designed for rugged service in appliances, automation and air conditioning equipment, solenoid, motor starting or heater circuits, battery chargers, clock controlled systems and similar commercial applications, "Diamond H" Series W relays will save space as they lower costs.

Measuring only 1½" x 1½" x 1⅞" (excluding spade terminals), they carry resistive loads up to 30 amperes at 115-230 V., A.C., while their weight is only 10 ounces or less, depending upon coil size and number of contacts. Six, 12, 24, 110 and 200 volt coils are standard but special coil windings can also be supplied.

"Diamond H" engineers are prepared to work out variations of Series W relays to meet specific requirements.

SERIES W RELAY DATA



Vibration Resistance: from 10 to 55 cps with 1/16" total excursion

Contacts: DPDT Double Break-Double Make
Maximum 2 pole Form Z
2 pole normally open
2 pole normally closed
Single pole Form Z
Single pole normally open
Single pole normally closed

Ratings: to 30 A., resistive, 115-230 V., A.C., and 1 h.p., 125 V., 2 h.p., 250 V., A.C. Other ratings on request.

Power Requirements: 1 watt or 5 VA and up, depending on vibration requirements and contact separation. Can be built to operate on A.C. or D.C. with voltages from a fraction up to 240.

Dielectric Strength: withstands 1750 V., RMS, between coil, or any terminal, and case.

Mounting Arrangements: Side, panel and socket mountings standard; others on request.

THE HART MANUFACTURING COMPANY

118 Bartholomew Avenue, Hartford, Conn.

Circle 537 on page 19

Just pick up your phone—

get price quotations, expert advice, prompt delivery

from your Superior Warehouse Distributor

Up against a tubing problem? Call your nearest Superior distributor. He's well stocked with quality tubing and information. Often he can make money-saving recommendations. Through his contact with the mill he can expedite information and orders for you. Let him show you why Superior tubing offers you real economy. Call on him today. He can save you valuable time and money.

For general information on Superior tubing, get a free copy of Bulletin 40. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 to ½ in. OD—certain analyses in light walls up to 2½ in. OD

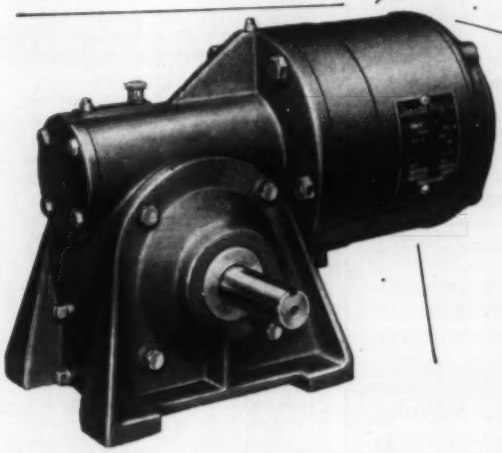
Circle 538 on page 19

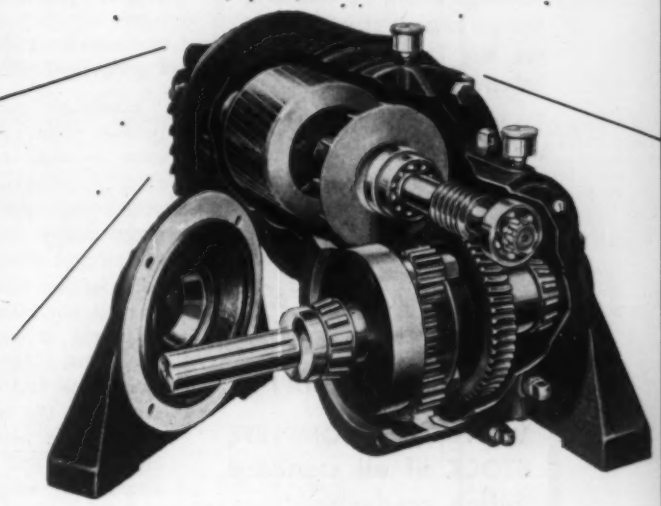
Circle 539 on page 19→

One touch of genius...

by the design engineer

and...





Production lines hum—transportation and distribution move fast to keep up with the pace of sales.

ONE TOUCH OF GENIUS back in 1910 by a Janette engineer made it possible for all design engineers to have at all times the exact precise control of speed and power needed to give them the right speed — the right power — in one single machine — in a wide variety of models — in any horsepower from 1/150 to 7½ in any needed mounting position.

When your design includes Janette gear motors and speed reducers — the great factor of the right speed and the right power is achieved. Then you have the opportunity to design that ONE TOUCH OF GENIUS into your product which will lift that product above all competitors.

Write for Janette Bulletin 5-105. Get the complete Janette story.

REPRESENTATIVES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Janette ELECTRIC MFG. CO.

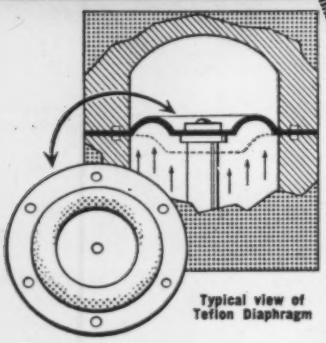
MORTON GROVE, ILLINOIS

for NEW PERSPECTIVES... let SPARTA help you put ideas to work with

CUSTOM MOLDED **TEFLON***

*DuPont's Tetrafluoroethylene Resin

IN THIN SECTIONS AND SHAPES!



Typical view of Teflon Diaphragm

Look to Sparta, pioneers in the development of custom molded Teflon parts (Pat. No. 2,781,552). Our highly trained Fluorocarbon engineering staff...modern manufacturing methods, are available to help you solve any design problems you may be experiencing with ordinary flexible materials.

The unique combination of properties of Teflon offers economical and product improvement opportunities never before possible.

When you think of **TEFLON** *think of SPARTA!*

We carry a COMPLETE STOCK of all standard Teflon products.

WRITE for complete data, prices, properties and applications without cost or obligation.

Dept. MD

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Division of United States Ceramic Tile Co.
DOVER, OHIO PHONE 4-2380

WESTERN DISTRICT OFFICE
Phone: ANGELUS 3-6359 Los Angeles, California

Circle 540 on page 19

Library

(*Continued from Page* 205)

translated from Russian periodical literature by Science Translation Service, University of Alabama for Bureau of Ships, USN; available from Office of Technical Services, U. S. Department of Commerce, Washington 25, *D. C.; 50c per copy.*

This report discusses the development of copper antifriction steels for cast machine parts. One type of cast-copper antifriction steel, tested in axle bearings and separator rings of ball bearings, is recommended in the report as an alternative for brass and bronze. Another copper-aluminum steel is recommended to replace metal-ceramics materials in the manufacture of heavy-duty and large-scale parts difficult to produce by powder metallurgical methods.

Bismanol Permanent Magnets, Evaluation and Processing, PB 121278. *By E. Adams and W. Hubbard, Naval Ordnance Laboratory; 19 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Department of Commerce, Washington* 25, *D. C.; 50c per copy.*

Bismanol permanent magnets possess remarkable flux constancy over a wide temperature range after stabilization at low temperatures and are extremely stable magnetically to shock, vibration, centrifugal force and stray magnetic fields. Except for a tendency to chip, the bismanol devices show sufficient strength for most applications. Improved fabrication techniques and equipment are described in the report. Methods of determining percentage of purity, alignment, and effective particle size in the magnets are also discussed.

NACA Technical Series. *Each publition is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1924 F St., N.W., Washington* 25, *D.C.*

The following Technical Notes are available:

3825. Comparison of Mechanical Properties of Flat Sheets, Molded Shapes, and Post-formed Shapes of Cotton-Fabric Phenolic Laminates—60 pages.

3828. Investigation of the NiA1 phase of Nickel-Aluminum Alloys—33 pages.

3913. Summary of 65-Series Compressor-Blade Low-Speed Cascade Data by Use of the Carpet-Plotting Technique—9 pages and loose plots.

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At Bendix Radio you'll find us acutely aware of your professional status, we have important, challenging work for *you* . . . and the way up the ladder of success is *faster*. That's because Bendix Radio is a respected leader in the development and production of the world's finest military and commercial electronics systems.

•

You will design mechanical and electro-mechanical electronic devices. Mechanical problems to be solved involve packaging, chassis, gearing, bearing surfaces, cooling and heat dissipation, shock and vibration, stress analysis and model shop techniques. You will supervise mechanical and electrical draftsmen.

•

You will benefit most at Bendix Radio, because of our *rapid expansion*. You will receive top pay, periodic merit reviews and *all* company benefits, including company assistance in graduate education. Our new, modern plant is located in a beautiful suburban area.

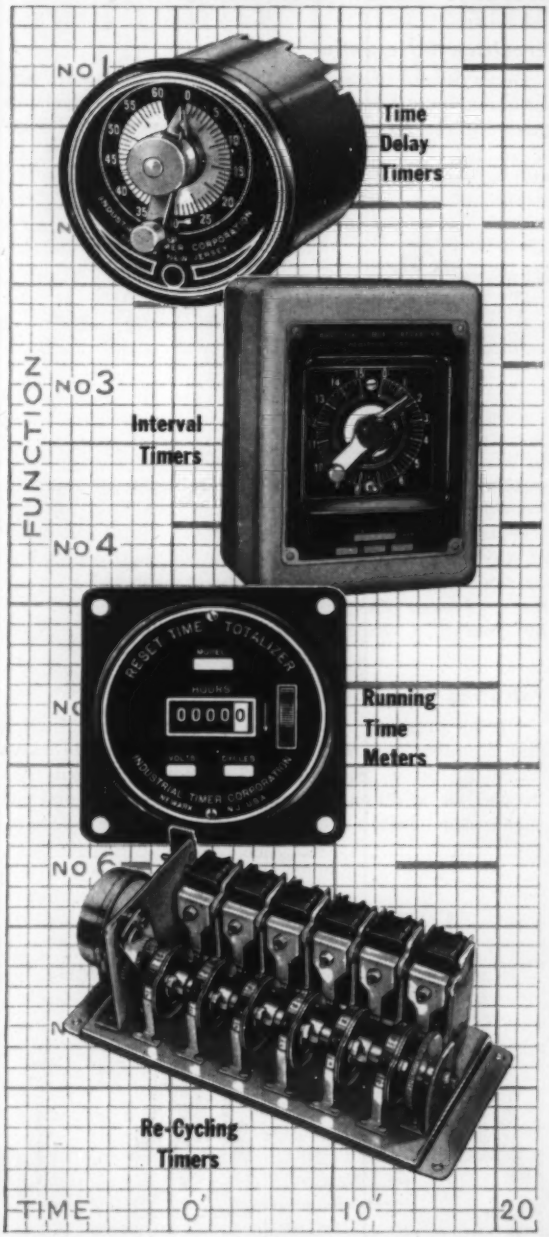
•

For immediate response, just drop us a postal card. Briefly state your education and experience.
Address:
Employment Supervisor, Dept. D

Bendix
DIVISION OF BENDIX AVIATION CORP
BALTIMORE 4, MARYLAND
Radio

Circle 541 on page 19

Need a "SPECIAL" TIMER ...need a "STANDARD"?



Here's why WE can give you the fastest service

When you want a timer, you want one that fits your needs 100% — and you want it *fast*. Get in touch with Industrial and you'll get both. Because:

In our 20 years of experience, we have developed over a *thousand combinations* from our 17 basic types, to meet the widely varying needs of our customers. Therefore — many jobs that would seem to require a "special" timer are in fact a "standard" timer with us. Here is one tremendous saving of time for you.

When you *do* need a special timer, this same wealth of experience goes to work for you at once to design it. Our Engineering Department not only originates new designs, but also develops modifications for that purpose. That's why requests for special timers can be filled without delay.

Each method — designing for a standard timer or for a special timer — has its advantages. Designing for an already available timer means lower costs, faster service, simplified replacements.

Designing for a special timer has its advantages too. It means you'll fulfill your needs 100% — no need to limit your designing horizons. Either way — standard or special — you'll get the timer you want most promptly from Industrial.

Or perhaps you need quick service on timers for automatic controls. Here too Industrial Timer is your first source of supply. For in this field Industrial has a big head start. True, each automatic control job is a bit different from the rest. But the record shows that our years of timer experience has given us the special knowledge it takes to give you the right answers in near-record time.

So, for the utmost in all-round timer service, it's Industrial that offers you this outstanding combination: deliveries "Immediate on Standards . . . First on Specials." Plus the experience of one of the foremost group of timer engineers in the nation.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

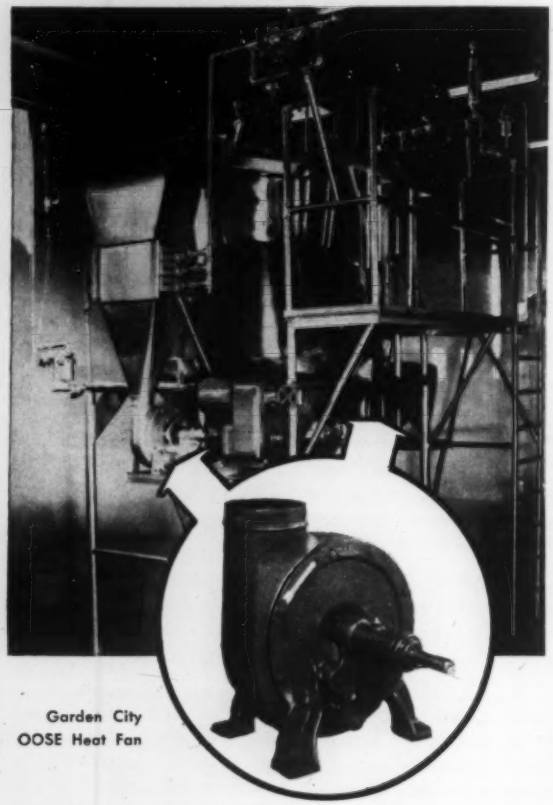
1413 McCARTER HIGHWAY, NEWARK 4, N. J.

Circle 542 on page 19

BLAW-KNOX* chooses

GARDEN CITY FANS

to change liquid milk into dry milk in their remarkable Instantizer!



Garden City OOSE Heat Fan

Fascinating—the way this fabulous Instantizer machine converts milk into powder form! First, the water is extracted . . . then the condensed milk-liquid is exposed to a current of hot, fast moving air (created by a Garden City OOSE heat fan) which effects immediate evaporation. Then another Garden City OOSE fan whisks away the milk powder in a conveyor.

You'll find Garden City fans in other blue-chip industries all over the nation. The advanced engineering features, remarkable efficiency level reported, and the low maintenance cost are among the many reasons why engineers are sold on Garden City.

**Dairy Equipment Division, Mora, Minnesota*

Write today for free booklet giving complete information.

GARDEN CITY FAN COMPANY
ESTABLISHED 1879

332 S. Michigan Ave.
Chicago 4, Illinois
Dept. G

Representatives in Principal Cities

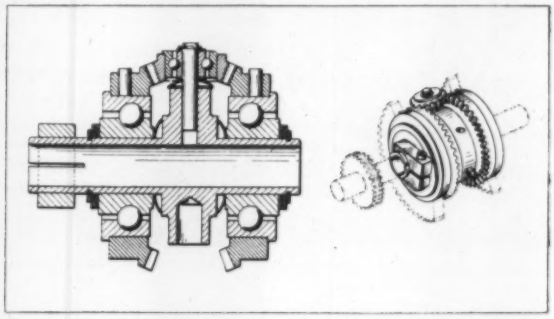
• Fans for Industry • Backward Curve • Forward Curve
• Material Handling • Radial Bladed • Small Exhaust

NOTEWORTHY

Patents

Precision Differential

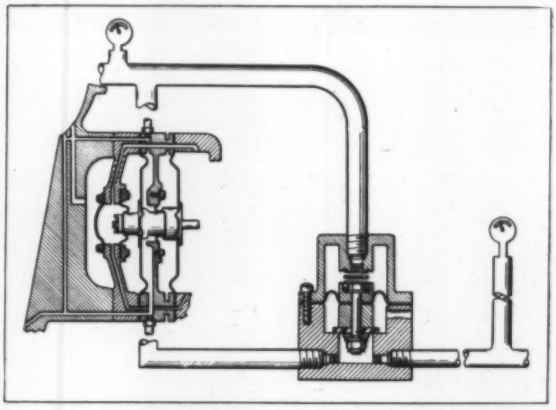
Drive shafts of varying lengths and diameters are accommodated by a hollow spider shaft in a precision gear differential. Designed for unit assembly in com-



puters and similar devices where gear or bearing wear leads to frequent removal or servicing, the differential can be used with side gears (light outlines) of any desired pitch or size. Unit is readily installed or removed without disassembly of associated equipment. *Patent 2,774,253 assigned to Librascope Inc. by Everett S. Minard and Frederick Lenzen.*

Pulsating Pneumatic Valve

Cyclic pressure pulsations at present amplitudes and frequencies are delivered by a pneumatic valve operating on a "make-break" schedule. Shown here in use as a diaphragm "exerciser" for an aircraft carburetor (left), the unit comprises a three-cham-



bered body and diaphragm-valve assembly. Upper and lower body chambers are suction chambers; center chamber is ported to atmospheric pressure. Vacuum applied through suction line (right) is bled through the lower chamber to the connected instru-

Flexon®

bellows and bellows assemblies

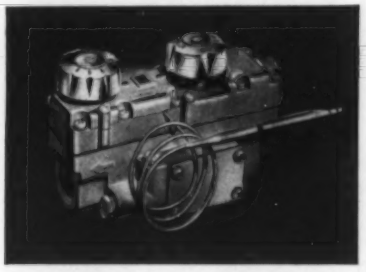
design and application briefs

How Honeywell Uses Bellows for Positive Temperature Control with Their Adatrol* Gas Valve

The V5153 Adatrol* Thermostatic Gas Valve, manufactured by Minneapolis-Honeywell Regulator Company is a 100% shut-off gas cock and a bellows-actuated snap-acting thermostat for gas heating devices.

How it Works

When the pilot flame is normal, the thermo-electric power generated by an appropriate pilot burner-thermocouple combination energizes an



Adatrol* Thermostatic Gas Valve.

electro-magnet in the Pilotstat to hold the Pilotstat valve open. However, should the pilot flame become inadequate for proper ignition of the main burner, the thermo-electric current quickly drops off causing the valve to close and block gas flow to the pilot and main burner.

Flexon Bellows is the Heart of the Control

Automatic temperature control is provided by the snap-acting thermostat section that incorporates a Flexon Bellows Assembly. The temperature sensing element (a bulb) is connected to the internal actuating element (a bellows) by a capillary tube. The bulb-tubing-bellows combination is completely filled with a hydraulic temperature sensitive liquid. Changing temperature in the area surrounding the bulb creates a changing pressure in the bellows, which actuates the valve.

Due to the small percentage of total fill in the bellows and capillary, the control is not appreciably affected by temperatures other than at the bulb location. Because it is a solid fill, instrument calibration is unaffected by altitude changes.

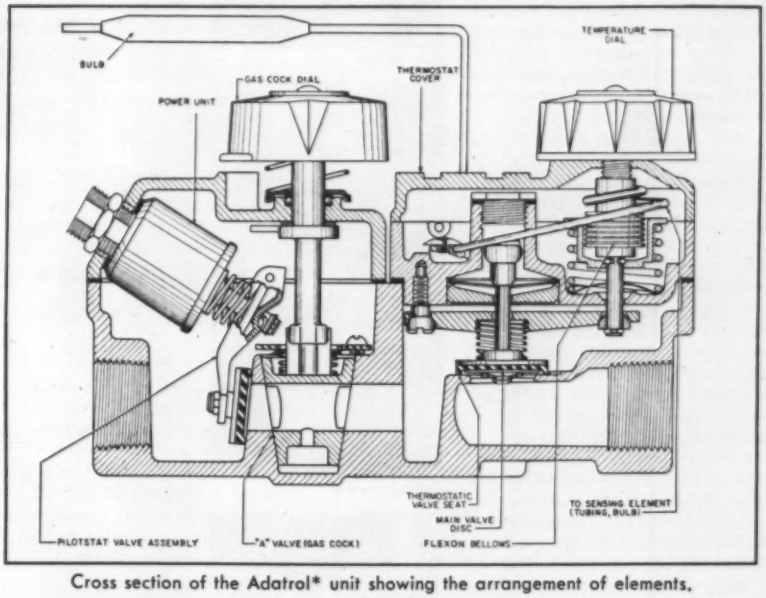
Why Flexon Bellows Are Used

Minneapolis-Honeywell uses Flexon Bellows Assemblies in the Adatrol* Valve to take advantage of Flexonics Corporation's facilities and bellows manufacturing know-how. Flexonics' application engineers are cost conscious, skilled in recommending the bellows or bellows assemblies that provide the performance required by the device at the lowest price consistent with these requirements.

View in Flexonics laboratories showing mass spectrometer being used to test bellows for leakage.

Engineering Assistance

The Flexonics Application Engineering Staff will be pleased to assist you in your bellows application problems. For specific recommendations send an outline of your requirements. For your bellows reference file, write for the Flexon Bellows Design Guide.



Cross section of the Adatrol* unit showing the arrangement of elements.

*Adatrol is the trademark of Minneapolis-Honeywell Regulator Co.

Flexonics® Corporation
BELLOWS DIVISION

1339 S. Third Avenue, Maywood, Illinois

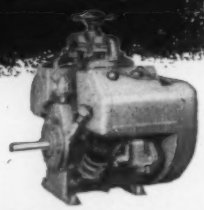
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Also Manufacturers of Rubber and Metal Hose Assemblies • Expansion Joints • Aircraft Components

Circle 544 on page 19

Your customers get...
PERFORMANCE that stands out
STAMINA that stands up

when you specify
WISCONSIN *Heavy-Duty*
Air-Cooled **ENGINES**



Whether you design and build farm or construction machinery, oil-field or railway-maintenance equipment, truck refrigeration units, irrigation pumping units, or any of the many other types of equipment that depend on engine power, you're always *right* when you rely on Wisconsin Heavy-Duty Air-Cooled Engines.

Supplied in a 3 to 36 hp. range, you get the power unit that matches the input requirements of your job *and* machine precisely. Your equipment is powered for peak performance and efficiency — without *underpowering* or *overpowering*.

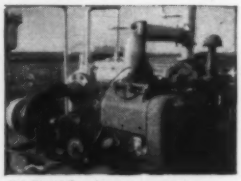
And Wisconsin basic High Torque design provides the dependable load-carrying Lugging Power that keeps the job moving through the shock-load pinches as well as maintaining a high power level under constant-load, continuous operation.

Rugged, inbuilt Stamina is another basic characteristic of all Wisconsin Engines because of their heavy-duty design and construction in all details, including such features as tapered roller bearings at BOTH ends of the crankshaft; rotary type high tension *outside* magneto; pump-circulated lubrication even on the smallest models . . . plus efficient AIR-COOLING at all temperatures from low sub-zero to 140° F.

When you specify Wisconsin Engine Power your good judgment is backed by over 2,200 Wisconsin Authorized Service Stations in the U.S. and Canada and in 82 foreign countries. Write for "Spec." Bulletin S-195 and tell us about your power problem.

Farm Service

Construction Service



Oil Field Service

Material Handling

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 46, WISCONSIN

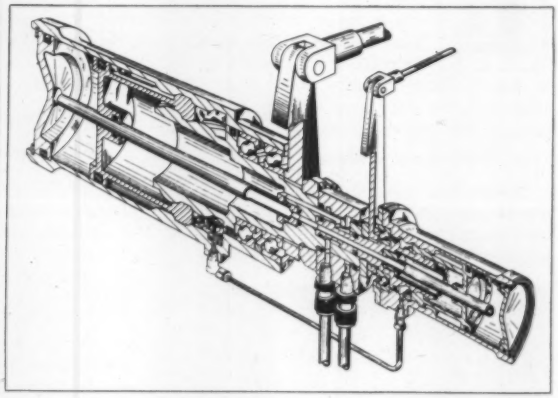
A 6-6000-½

Noteworthy Patents

ment. When pressure in upper chamber drops, make-break valve opens, connecting lower chamber to atmospheric-pressure source. Pressure pulse is then transmitted to the connected device and the cycle repeats. *Patent* 2,774,370 *assigned to Bendix Aviation Corp. by Howard L. McCombs.*

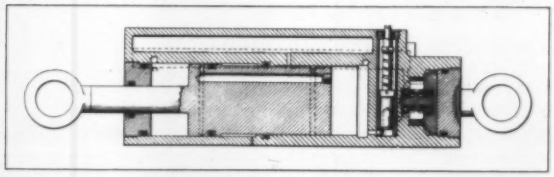
Load-Sensing Actuator

Force feedback from load-linkage (left) to operating linkage (right) provides the operator of a rotary-type hydraulic actuator with a "feel" proportional to the magnitude of the driven load. Angular movement of operating linkage is converted to identical movement of load linkage by a power-amplifying hydraulic piston assembly. Conversion of linear to rotary piston movement in the unit is accomplished by a helically splined cylinder and mating piston. *Patent* 2,774,337 *assigned to General Motors Corp. by Howard M. Gayer.*



Frequency-Sensitive Vibration Damper

Fluid displacement damper in which elasticities of mechanical components, as well as compressibility of the damping fluid, are considered in the unit design provides high vibration-absorbing capacity per unit weight. Comprising a movable piston, which displaces fluid from one end of a cylinder to the other through a long passage, the unit incorporates a small fluid motor as a means for increasing the effective inertia of the fluid. Damping capacity of the unit peaks at a desired vibration frequency, falls off to low values at frequencies outside the design range. *Patent* 2,777,544 *assigned to Houdaille Industries Inc.*



NEED A *SPECIAL* RUBBER PART TO LICK A TOUGH PROBLEM?

PHOENIX 4-STEP SERVICE

assures a better end product

Compounding special rubber to meet specific product requirements has been a Phoenix specialty for over 25 years.

Phoenix 4-Step Service can help you use natural or synthetic rubber in designing a better and often cheaper end product:

We will (1) analyze your problem, (2) assist in designing the rubber component, (3) compound and test the most suitable rubber and (4) manufacture the part with traditional Phoenix craftsmanship.

A Phoenix representative will gladly show you how Phoenix 4-Step Service can help you lick a tough product problem, as it did in case of the flexible coupling below.

THE CASE OF THE FLEXIBLE COUPLING

A flexible coupling component of an automobile window and seat assembly called for rubber bonded to nylon. The problem was to retain this bond under extreme torque running as high as 180°. Additionally, the rubber must not rupture, must be resilient and flexible to all temperatures and be resistant to oil. These characteristics must be retained for the life of the car.

Phoenix compounded a special synthetic rubber with all of the properties required and successfully bonded it to nylon. The component has surpassed all expectations, thanks to Phoenix skills with rubber.

Leading Manufacturers of Custom Molded Mechanical Rubber

PHOENIX

RUBBER PRODUCTS DIVISION

PHOENIX MANUFACTURING COMPANY

JOLIET, ILL. • FOUNDED 1862

Integrated Manufacturing Facilities: RUBBER PRODUCTS DIVISION, OIL AND GREASE SEAL DIVISION, FLANGE AND FORGING DIVISION, STEEL MILL DIVISION, HORSESHOE PRODUCTS DIVISION

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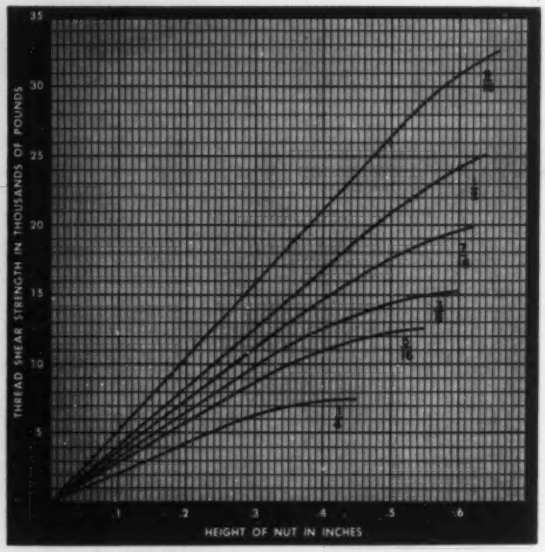


Shear Strength...

Finished HEXAGON NUTS

fine and coarse threads

The above curves show how the proof load of a nut (the load causing the threads to strip) varies with its height. (The curves do not account for bolt characteristics or fatigue and safety factors.)

If you are buying load carrying capacity, the curves suggest that it may be more economical to:

1. Use a thicker nut—
2. Increase the fastener size—
3. Use more and smaller fastenings—
4. Use heat-treated nuts to develop full bolt strength (heat-treating increases nut proof load 30 to 50% over the above values)—

Variables of economical fastener design selection and assembly are discussed in the Engineering Data section of our catalogue that we will send upon request.

NATIONAL MACHINE PRODUCTS COMPANY

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts..."Huglock" and "Marsden" locknuts.*

44255 Utica Rd., UTICA, Michigan

Balance is in the knurled finger grip for effortless pencil control.

Hardened steel spring loaded clutch grips lead securely — will last for years.

$1.85

Push button anodized red, blue or yellow for quick identification.

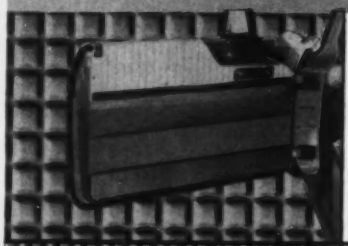
Ask your supply house or write for descriptive folder and name of nearest distributor.

RICHARD BEST PENCIL COMPANY
SPRINGFIELD, NEW JERSEY

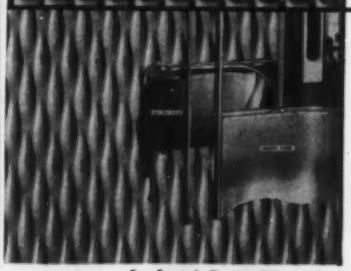
Circle 548 on page 19

RIGID-tex METAL

demonstrates its Superiority
ON THE ROAD



Where kicks and scuffs are routine — RIGID-tex Metal will take it and remain new looking always — like the kick-plate on this modern automobile door. (Pattern 1-SQ)



Bus seat backs of stainless RIGID-tex Metal (pattern 5-WL) withstand kicks, scuffs—even knifing. Reduces maintenance costs. Used too for modesty panels, treads, etc.

See Sweet's Design File 1a/Ri or write for more information.

RIGID-tex METAL IT'S RIGIDIZED

RIGIDIZED METALS CORPORATION
6934 OHIO STREET, BUFFALO 3, N. Y.
World-wide Distribution

Circle 547 on page 19

Circle 549 on page 19

Linkage

The Long and Short of it . . .

HEIM *Unibal* Rod Ends

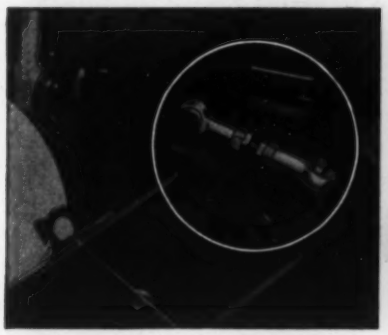
make an Infinitely Adjustable Linkage

For a short connecting rod, an externally threaded male Heim rod end can be screwed into an internally threaded female rod end to give smooth transmission of power or force.

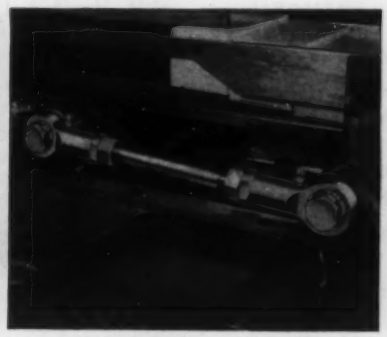
Longer connecting rod assemblies are just as simple to make by using the proper length of tube or rod between Heim rod ends.

The push-pull rods or linkages can be assembled by riveting, by swaging, by welding, or by threading and locking with set screws or lock nuts.

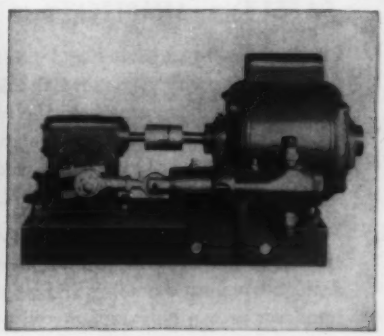
Heim Unibal Rod Ends are self-aligning, they reduce friction and lost motion, and they are economical in price and in installation time.



A short length of rod, threaded at both ends to fit two Heim Unibal female rod ends, is used on this Foster Machine Co. Model 75 pineapple coning machine. This machine is used for winding nylon, and rayon yarns to packages for use on full fashion knitting machines.



A longer length of rod, with two Heim Rod Ends locked in position with hex nuts, actuates the feed on this cartoner made by R. A. Jones & Co. Jones Constant Motion Cartoners handle millions of bottles, jars, tubes, etc. every day in a wide variety of packaging.



A male Heim rod end screwed into a female rod end forms the short linkage necessary on this Milton Roy pump. The self-aligning feature of Heim Unibal corrects the misalignment between the crank arm and the plunger moving in the pump frame.

The Heim engineering department will be glad to assist in solving your linkage problems. The Heim catalog should be at your fingertips. Please write.

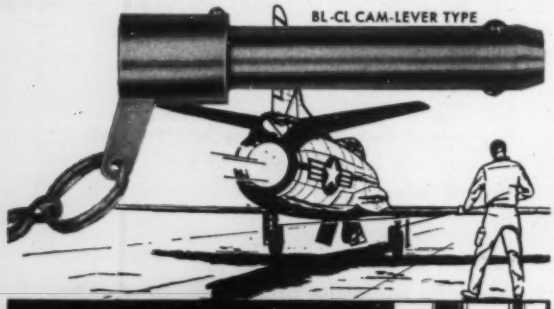
THE HEIM COMPANY / Fairfield, Connecticut

Ball-lok pin

the positive locking pin with quick release

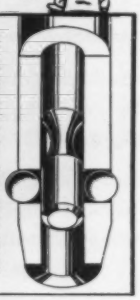
whenever units are frequently assembled or disassembled

REG. U.S. PAT. OFF.



Precision BL-CL pull pins are especially adaptable for blind or hard-to-get-at places. Pin can be removed by simply pulling or attaching a cable or lanyard to pull from a distance.

The positive self-locking BL-CL pin is the perfect answer for the *safe — fast way* to release the Landing Gear Safety Locks on many models of military and commercial airplanes.



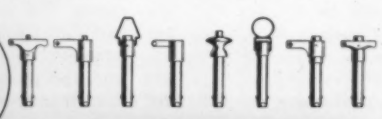
SAFETY • SIMPLICITY • STRENGTH

For highest dependability and safe-fast economical service . . . specify precision Ball-lok pins. The simplicity of less moving parts in the single action pins assures you of trouble-free operation. Completely eliminates all need of nuts, bolts, washers, clevis pins or other retaining items. NO TOOLS NEEDED.

Millions of hours in service under every possible operating condition have proved their dependability. Available in most diameters and lengths to usual bolt standards or can be manufactured to your specifications.

WRITE FOR FREE ILLUSTRATED BROCHURE 602 ON ALL STANDARD MODELS.

Ball-lok pin



manufactured by d.w. rice corporation

11161 West Pico Blvd. Los Angeles 64

national sales representatives ROWE SALES CO.

Circle 551 on page 19

MAYLINE

Convenience in the Drafting Room

Only the May-O-Matic table gives the draftsman filing and reference combinations of auxiliary drawer unit, 5 drawer plan file, bookshelf, and sliding reference top,—convenience at its best.

Get the facts on this advanced automatic drafting table. See your local dealer today.

Symbol of MAYLINE *Superiority*

METAL PLAN FILE

MAYLINE CO., INC.
601 No. Commerce St.
Sheboygan, Wisconsin

MAYLINE

Circle 552 on page 19

WECKESSER

molded **BLACK NYLON SCREWS** *and* **NUTS**

Acid resistant . . .
Need no insulation . . .
Can't rust . . .
Can't corrode . . .

● **CUT ASSEMBLY TIME**
4-40, 6-32, 8-32, 10-32 and ¼-20 in stock. Actual production samples will give you the whole story. Write on your letterhead.

WECKESSER COMPANY
5715 Northwest Hwy. • Chicago 30, Ill.

Circle 553 on page 19

FREE UPON REQUEST—

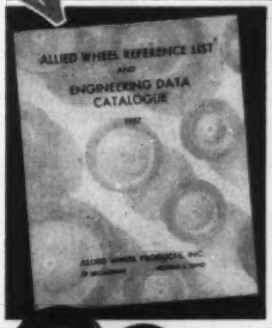
COMPLETE NEW CATALOG

ENGINEERING DATA

And REFERENCE LIST On

WHEELS

TIRES—HUBS BEARINGS



Every design engineer and procurement official needs this comprehensive data book for easy reference and guidance. A "must" for all producers of items that roll on juvenile, light or heavy duty industrial wheels.

GET YOUR COPY NOW

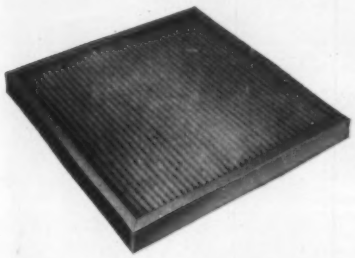
To obtain your FREE copy, just write us on your letterhead. Supplementary data sheets will be sent you as they are released.

ALLIED **ALLIED WHEEL PRODUCTS, Inc.**

Dept. MD• 27 BROADWAY • TOLEDO 4, OHIO

Circle 554 on page 19

NEW DRY-TYPE WASHABLE AIR FILTER



A new air filter by Air-Maze combines the efficiency of a dry, oilless, completely washable panel with a greatly extended filtering surface for longer service life. Has over 8 times the effective surface area of a conventional panel. Especially efficient in removing lint from recirculated air, and for applications where oil vapors cannot be tolerated.

Special screen grids on both sides of filter permit lint to be brushed off several times before washing is necessary. Filter offers complete washability in cold water. May also be cleaned with a vacuum nozzle.

Made of corrosive-resistant materials—aluminum screen and polystyrene-bonded fiber glass media in galvanized channel.

Available in 2" thick panels—16" x 20", 16" x 25", 20" x 20", and 20" x 25" sizes. Write for Bulletin P70P, **AIR-MAZE CORPORATION**, Cleveland 28, Ohio.

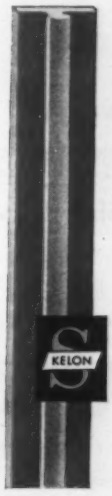
Circle 555 on page 19

in the best possible shape

SHAMBAN

TEFLON EXTRUDED PROFILE SHAPES

whatever the shape — whatever the need — a SHAMBAN TEFLON* shape will fill it better because of Teflon's* unusual properties . . .



INERT TO VIRTUALLY ALL COMMERCIALLY EMPLOYED CHEMICALS AND SOLVENTS
HEAT RESISTANT
TOUGH AND FLEXIBLE at extremely low temperatures
ADHESION RESISTANT — low coefficient of friction
WEATHER RESISTANT
ZERO MOISTURE ABSORPTION (by A.S.T.M. Test)

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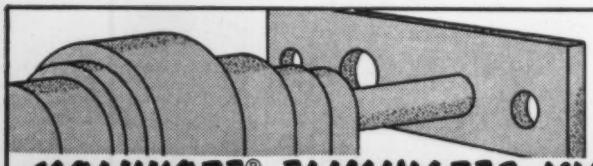

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Here's the way this report came to us:

"On a heavy cylindrical grinder, the grinding head which weighed 8,000 pounds had to be moved hydraulically at feed rates of .00025" per second. It turned out to be an impossible job with oils and greases. Finally, we cleaned the ways with benzine and rubbed in MOLYKOTE, Type Z powder. It sure was a relief to see the grinding head move without the previous jumpy, stick-slip behavior."

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- . . . reduced friction 30% on rubber "O" rings, packings and seals.
- . . . multipled number of operating cycles in valve test 5 times.
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753

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*made to S.A.E. and Federal Govt. Specifications

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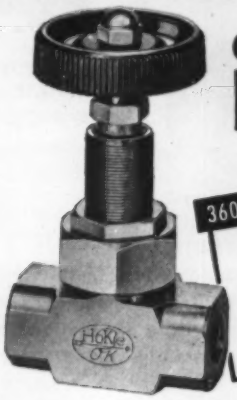
Circle 559 on page 19

HOKE announces

10 valves in 1



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Fluid Control Specialists
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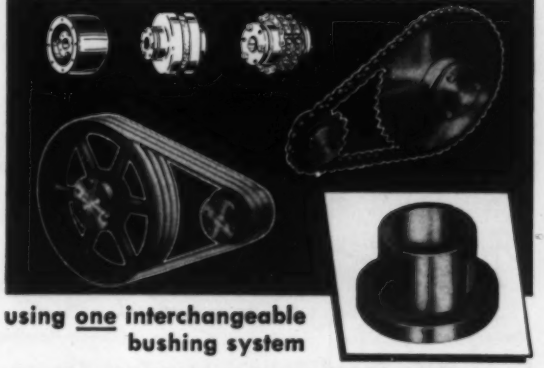

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Browning POWER TRANSMISSION EQUIPMENT

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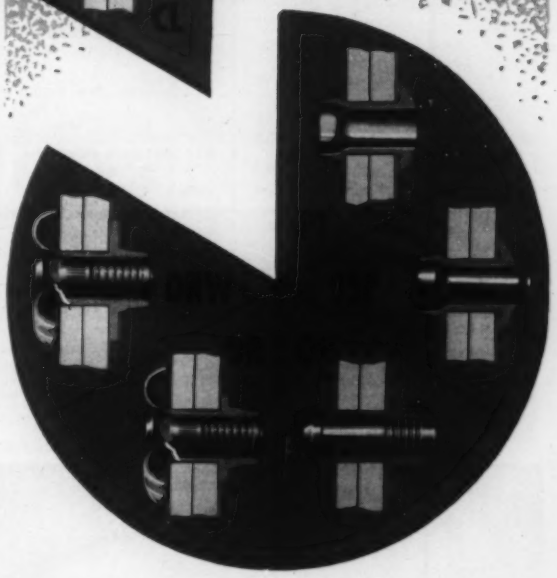
there's a HUCK FASTENER TO MEET YOUR REQUIREMENT



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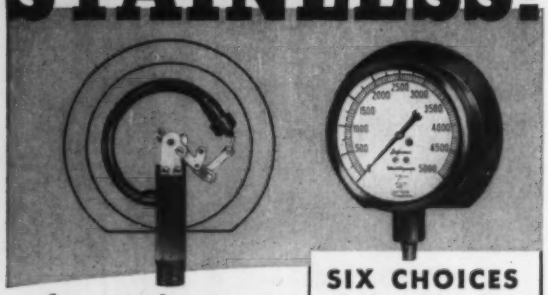

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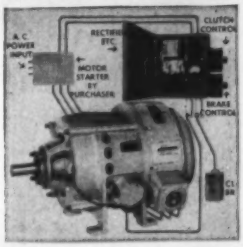

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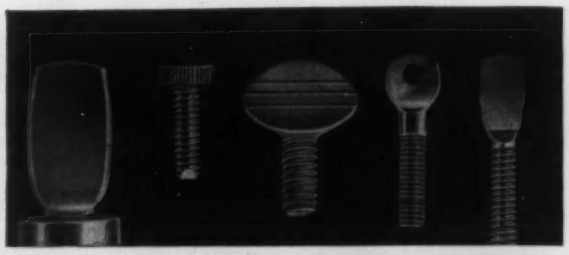

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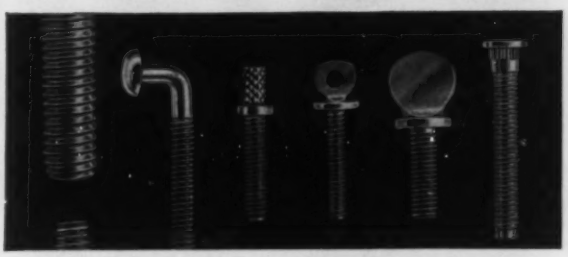

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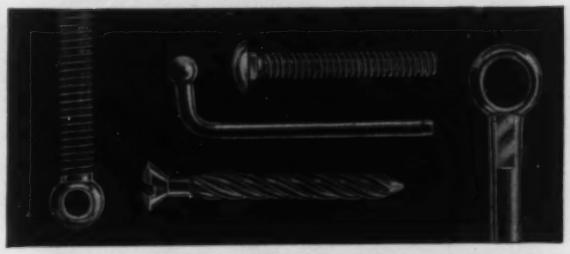

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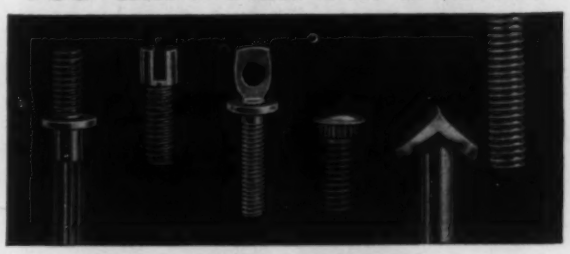

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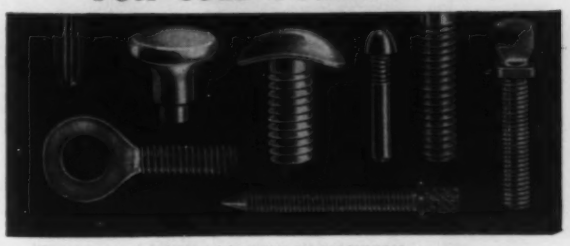

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Parker
Hydraulic and fluid system components

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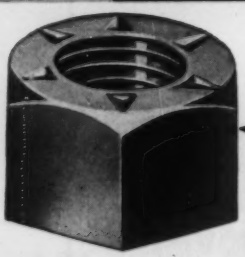
SPECIFY GRIPCO LOCK NUTS



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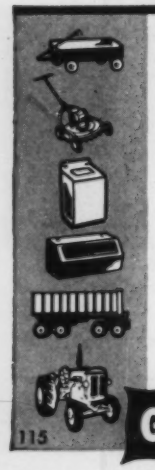

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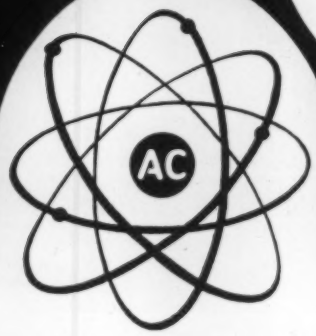

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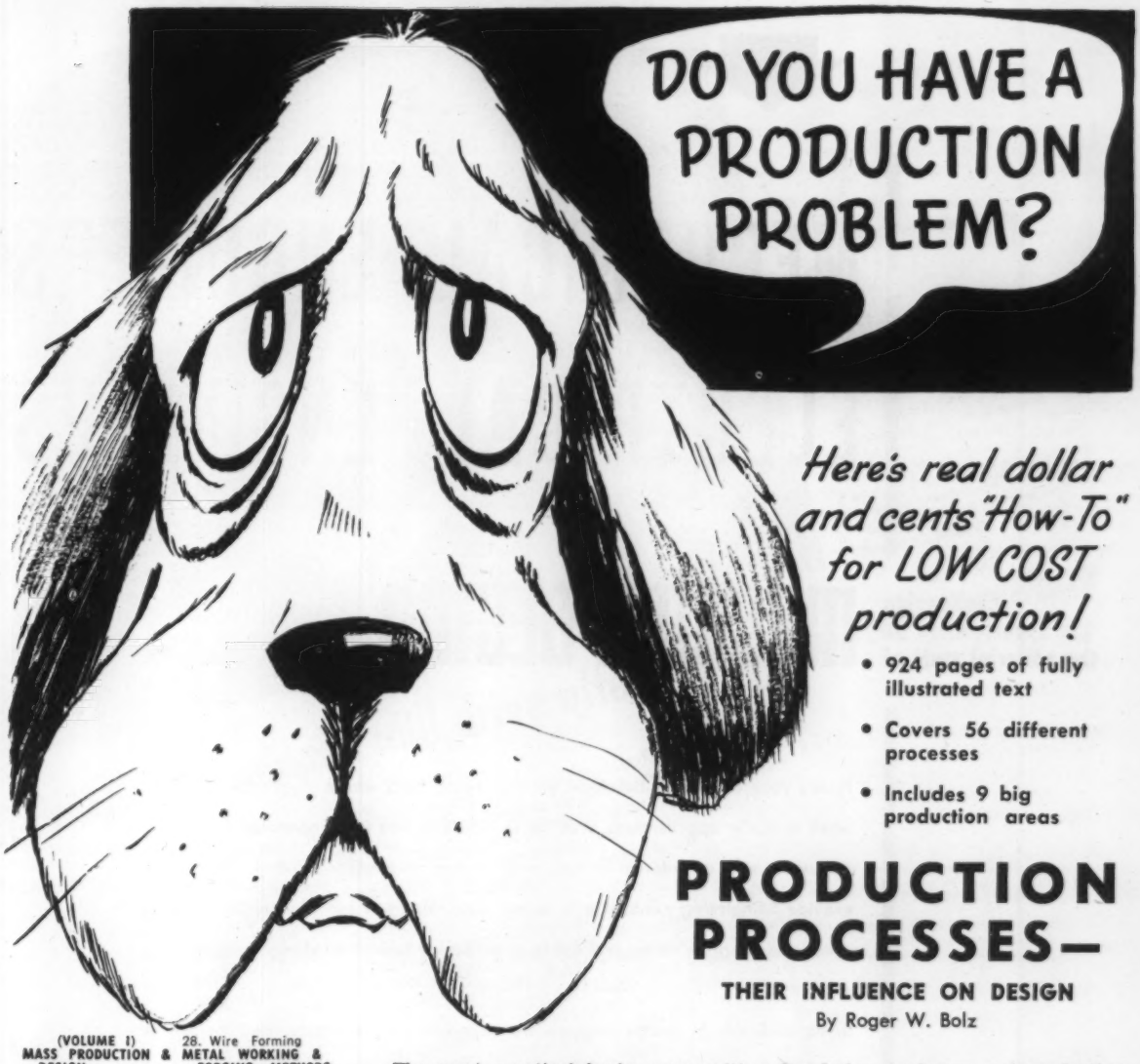

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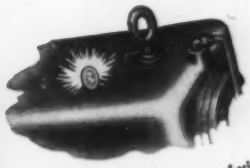

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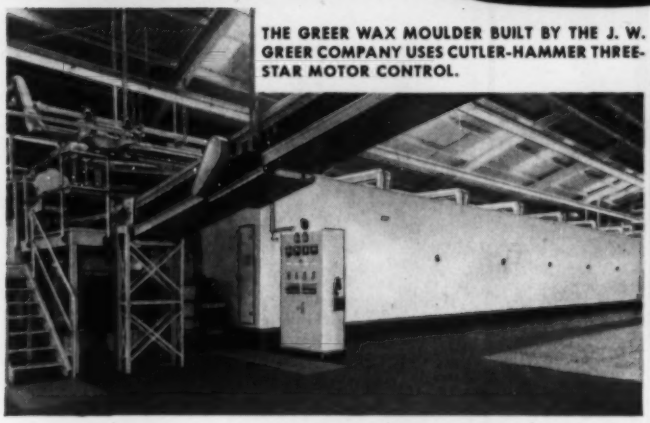

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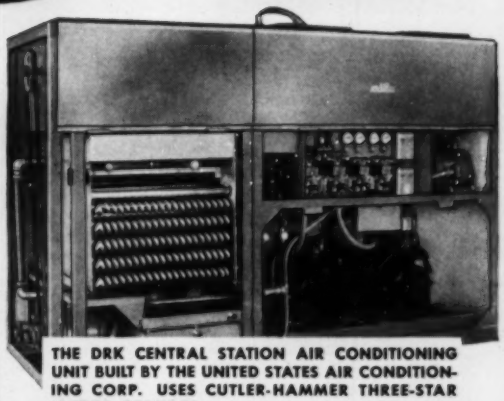

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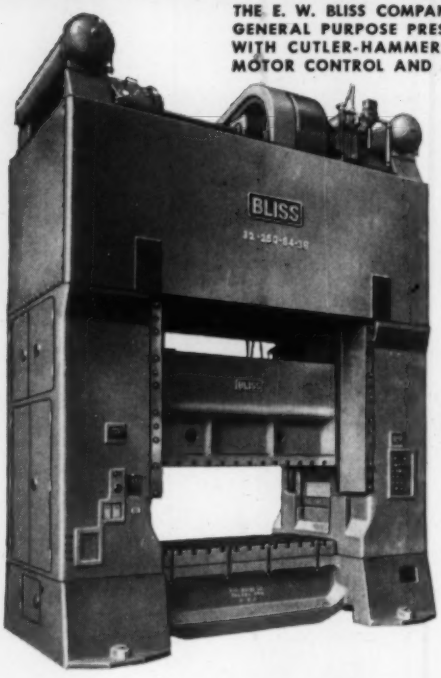

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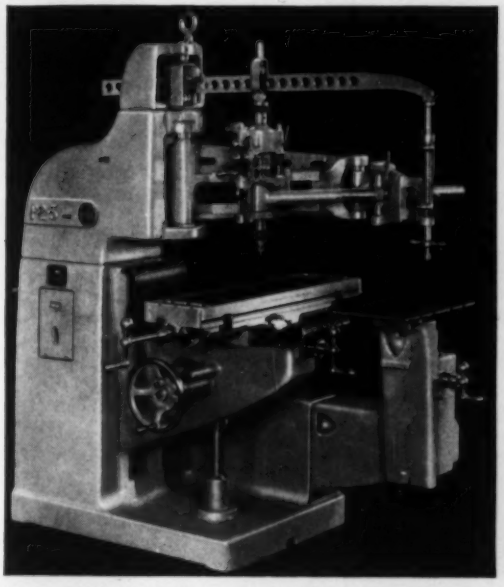

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